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APPLIED MECHANICS REVIEWS

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SOIL MECHANICS

ÁRPÁD KÉZDI

TECHNICAL UNIVERSITY, BUDAPEST, HUNGARY

IN soil mechanics, the science dealing with relationships between soil and engineering works, three principal trends are observable. Chronologically, the first was the purely empirical method, based exclusively on experience obtained from attacking soil engineering problems and on the argument that the infinitely great variety of soils renders impossible the establishment of exact laws. All scientific investigation was refuted; at most, the reason for some simple experiments on soil identification was admitted.

The second trend may be considered as a continuation of research in mechanics started in the wake of the natural philosophy of the 19th century: the soil was supposed to be characterized by some independent physical data; for the mathematical treatment of the problem, assumptions were made which are more or less abstracts from reality, and further investigation was concerned only with the perfection of mathematical-mechanical solutions. The hypotheses upon which these theories were based are regarded at present as classical: Hooke's law, Darcy's law, coefficient of subgrade reaction, etc. This trend has produced theories involving the use of intricate mathematical apparatus and thereby suggesting absolute precision and reliability; regarding this trend, Terzaghi properly stated that the refinement of the mathematical solutions was disproportionate to the importance of errors arising from the simplifying assumptions.

The third trend does not claim exclusiveness either for empirical observations or for theoretical investigations; instead, design is based on theories which are as simple as possible, as well as on physical characteristics of the soil established by field or laboratory tests. Theory, however, is regarded only as a working hypothesis; the uncertainties inherent in the basic assumptions of the calculations are recognized and, consequently, the observations and measurements to be executed during construction can be programmed and their results evaluated. This approach is the living guide to action for the soils engineer of today.

Soil mechanics is a border science, verging on the quantitative attribute of engineering design and on the qualitative domain of geology. Its greatest merit consists in having introduced concepts of mechanics into geological thinking; in having dissipated numerous superstitions and misbeliefs relative to the behavior of the soil, treated earlier with a certain mysticism; in having established methods of soil testing and of conducting laboratory tests; and in having advanced the techniques of theoretical treatment, which always allow qualitative and, in many instances, quantitative investigation wherever there exists a correlation between engineering work and subsoil.

In the literature of soil mechanics, during the first period (1925–1940) after the publication of Terzaghi's fundamental work (1),[1] a multitude of papers came out all over the world, often containing controversial results and theories based upon incorrect assumptions or extrapolations. This exploratory phase, composed of feverish experimentation, and both laboratory and theoretical research, was necessary to elucidate concepts; to calm down exaggerated hopes associated with soil mechanics, i.e., the assumption that soil problems could eventually be solved on a sound theoretical basis similar to that existing with regard to problems relating to steel structures; and to gather experience on engineering works designed and built, based upon soil mechanical tests and expert opinion. Soil mechanics arrived at this stage of development in the late 1940's; the first comprehensive basic books published closed this period (2–12) and fixed the valuable and permanent results.

1 SUBSURFACE EXPLORATION

The first and most important step in investigating the subsoil is to clear up its conditions. The most perfect synthesis of methods developed in the process of evolution has been given by Hvorslev (13) who also compiled an almost complete bibliography. More and more extensive application of geophysical methods (14) may be expected in the future; of these, the geoelectric method (15), marked by simplicity and utilizing test borings, appears the most commendable. The theory underlying this method is developing more and more (16).

2 SOIL PHYSICS

Soil mechanics, as a science investigating the properties of solid-liquid-gaseous dispersed materials, will soon develop, not as applied mechanics, but as applied physics and chemistry. This is

[1] Numbers in parentheses indicate References at end of paper.

evidenced especially in the examination of soil structure. Research on the mutual effects of the individual component phases by methods of colloidal chemistry is progressing (17); the effect of chemical composition upon physical strength properties arouses the most interest.

As to the routine laboratory testing methods of soils, a certain conservatism is observed in methods fixed about 25 years ago; the determination of the grain-size distribution curve, of limits of consistency, of unconfined and confined compression, and of other factors is being used almost invariably. (Books recapitulating them: 18-21.) This fact is for the most part explained by the vast experience gathered in connection with these physical characteristics and based upon them. Soils engineers have already learned to think in these terms and numerous statistical relations, at least of regional validity, have been fixed. To replace them by new ones (22) raises difficulties. Although these physical constants describe adequately the soil properties, characteristics hitherto used do not give, in many cases, full information; for instance, the grain-size distribution curve and the void ratio alone, especially in sandy soils, do not at all characterize the soil structure.

In the study of fine grains, the science of micromeritics is very helpful (23).

The problem of the stress-strain ratio has not been settled either; the general law of strain is still wanting, and so is the development of a nonlinear theory of soil strength.

Extensive research is being conducted on the problem of shear strength (24–27). Researchers agree that the application of triaxial compression tests is the most correct approach (28), but the mode of execution is still in dispute. The most acceptable opinion is that the design shear test is determinable by an exact as possible reproduction of expected actual conditions (12, 26).

In general, theories in regard to the shear stress of soils are based on the following assumptions: (a) The value of shear stress can be written down from the Coulomb-Hvorslev equation (29); (b) the shear stress is a unique function of the moisture content. Some researchers argue that the moisture content is only a function of the variation of the major principal stress. Use of shear-stress results is very much inhibited by progressive shear failure and by friction between the soil and metal frame. We still know very little about the behavior of cohesionless soils immediately in the shear zone, especially in the case of small dislocations; it is probable that slip does not take place on a definite plane but within a closed zone. Problems of shear stress and strain, that of the relation of stress-strain in different soils, may well be called the basic problem of soil mechanics.

Routine principles of material testing were not logically applied in soil physics in earlier days. At that time (and often even now) material testing applied certain arbitrary testing methods in the different fields and specified certain conditions to be observed in the use of the material for a given purpose. The connection between the two sides—testing and design practice—was, in general, established by experience only. For instance, the behavior of the material during the model test for strength is essentially different from that of the prototype.

In soil mechanics, on the other hand, the early experimenters claimed that the laboratory strength test result (e.g., the unconfined compression strength of a cylinder of 1-in. diam and 1.5-in. height) could be directly applied to the calculation of a retaining wall or of an embankment of 30 to 40 ft in height. Since this method could not be successful, large scale tests in the field have come into prominence (30, 31) and test loading has again been accepted as a standard, although with other aims and for other uses (10, 12, 18). Further experiments have been conducted to establish the model laws of laboratory tests (32–34) through the analysis of the stress conditions of the loadings applied at the test.

Field tests (e.g., soundings, standard penetration resistance test, vane test, etc.) are widely used for the determination of the "in-situ" shearing strength; they suit very well as a means of obtaining quick information.

Statistical relations of regional importance, establishing connection between index properties of the soil and its physical properties of importance for engineering design, may be very helpful.

3 SPREAD FOUNDATIONS

For the investigation of the load capacity of spread foundations, two principal methods have been developed. The first examines, on the basis of the theory of elasticity, the stress distribution in soil as a semi-infinite, elastic, isotropic body; compares the maximum shear stress occurring with the shearing strength of the medium; and regards as ultimate load that which develops at the most unfavorable place a shear stress equal to the shearing strength of the medium. Since the behavior of the soil when stressed close to the shear strength is not at all elastic, it appears more expedient in the future to execute computations similar in character but based on the principle that the maximum shear stress does not exceed the experimentally determined stress that produces approximately linear strain.

A development of the above method is the investigation of plastic zones developing in the soil which, following the ideas of Fröhlich (35), has found extensive application; e.g., Lorenz (36), Jaropolski (37), Pusirevski (38), Maslov (39), etc. A shortcoming of all these methods is that the theoretically determined borderline between elastic and plastic zones is but fictitious, because stresses are calculated even within the plastic zone on the basis of the theory of elasticity; the coefficient of earth pressure at rest in the soil, in general less than unity, is disregarded. Results thus obtained serve only for relative comparison of given stress conditions.

The other approach is through the theory of plasticity (2, 40, 41, 42, 43). Suppose that the soil is an ideal plastic incompressible medium; under increased loading it develops into an entirely or partly plastic state, and slip surfaces then occur. In the analysis of the limit state of equilibrium of the earth mass, the minimum surface load is sought which produces this state; this is, then, the ultimate bearing capacity of the soil, producing complete shear failure of the entire body. This method appears in general advantageous, especially for soils that fail by definite bearing which has been found to be in good agreement with results of loading tests, although not providing information relative to the problem of safety.

Methods applied in the calculation of settlement are also dealt with in the literature with increasing frequency (44, 45) as nowadays, under permissible bearing pressure, a stress-producing allowable settlement is understood.

The preliminary condition of dependable settlement calculation is a stress-distribution theory approaching reality as closely as possible. In this field, the use of methods of the classical theory of elasticity is still the most universal (46) with, of course, the postulate that boundary conditions of the given case have to be considered. Thus, effects of the deepening of the foundation body and of shear stresses developing on the base plane must not be disregarded (47, 48). Consideration is given to the aeolotropy of the soil in recent papers (35, 49, 50).

Existing theories call for verification by direct measurement; this poses, especially in regard to cohesive soil, insurmountable difficulties for the time being.

In the calculation of settlement, Meyerhof (51) suggested a

new idea, aimed at the precise consideration of the mutual effect of structure and subsoil; further, the first steps have been taken to investigate the time rate of subsidence of statically indeterminate structures (12) in order to consider load displacement caused by settlement, which decisively affects differential settlement and is of great importance in determining the play of forces in the structure.

In the examination of the time rate of settlement, the original Terzaghi-Fröhlich theory has been extended and founded on a new basis. Florin (52) derives, by reason of the generalized Darcy-Gersevanov law, a general relationship for the time rate of compression of not entirely saturated earth masses, in the case of three-dimensional water flow and loading which is variable in time. These results have been made useful for practice by Karafiáth (53). A solution for the case of a concentrated force has been given by Mandel (54).

Latest research is engaged with the problem of secondary consolidation and with that of the critical hydraulic gradient, which just starts water flow, in contrast with latest results attained in the theory of seepage (55).

For the consideration of the layered state of the soil and of the variation of its moduli of compression, theoretical solutions are known only in some very simple cases. Such is the theory considering the effect of a solid lower layer (48), the theory supposing a linear increase of compressibility with depth (35), and the solution of the stress state of a two-layer system referring primarily to the case of road pavements (9).

A very important aspect of the problem, especially in foundation work of smaller structures, is the investigation of the physical laws governing swelling and seasonal changes of soils (56).

Jelinek, Jegorov, and Tettinek-Matl (57–59) treat the problem of dip of eccentrically loaded foundations; however, they generally disregard the effect on the general stress distribution of frictional stresses occurring on the base plane; this has a considerable influence in such cases.

The problem of deformations of layered or anisotropic systems is not properly elaborated. In research in this field, the theory of bending of soils will surely play an important part.

The theory of calculation of elastically supported foundation bodies has resulted in several mathematical-mechanical masterpieces, stemming from Zimmerman's classical basic studies; their common shortcoming lies in the general use of the artificial concept of the coefficient of subgrade reaction. We will probably still have to wait a very long time for the solution of the general integral equation of the semielastically supported beam resting on soil, considering the real, nonlinear behavior of the soil which, moreover, replaces the Navier hypothesis of bending with better approximation. Meanwhile, we shall have to be content with procedures using a coefficient of subgrade reaction depending on the dimensions, rigidity, and depth of the foundation, which is regarded as constant only from section to section (60).

4 PILE FOUNDATIONS

Disputes about the pseudoscientific pile formulas have been roughly settled; their strongly limited applicability and their poor scientific foundation have been made evident (61–63). At present, tests made with the use of modern measuring instruments are in the foreground (64–65); these register pile-driving much more exactly than before and the results are very promising. In the question of the carrying capacity of piles, we still miss a theory which would yield the limit carrying capacity—with adequate consideration of deformation, and based on the cooperation and mutual effect of tip resistance and of mantle friction—at least in homogeneous soil, or in the case of a simplified ground cross section. By separating the tip resistance and the mantle friction, the older theories approached the problem in absolutely the wrong way; the use of the theory of earth pressure acting on retaining walls and the neglect of the three-dimensional stressed state were further errors of principle. It became further evident that the ratio between the settlement of a pile foundation and the settlement of a single pile under design load may assume very different values. The settlement of one pile depends only on the soil surrounding the pile, but the settlement of the complete pile foundation depends on the number of piles and, above all, on the compression of the layers underneath the pile tips. The latest investigations also point out that, under certain conditions, the carrying capacity of a group of piles is greater than the product of the carrying capacity of one pile multiplied by the number of piles. These problems will be clarified by comparison of settlements of pile load tests and of structures on pile foundations. Research offers the hope that the two trends of investigation into the carrying capacity of piles, i.e., the purely statical course and the purely soil mechanical tendency, will approach each other and will yield the basis for development of the afore-mentioned uniform theory.

5 EARTH PRESSURE

Problems of earth pressure in the broadest sense are concerned with stresses arising in the inside of earth masses, or on the surface of structures in contact with them.

In the problem of earth pressure acting on retaining walls, an interesting situation has developed. The classical earth-pressure theory, founded in 1776 by Coulomb and introducing basic concepts and assumptions, still holds; practical textbooks (e.g., 46) make use almost exclusively of generalized methods of the original Coulomb theory, maintaining the condition of extreme value, the plane slip surface, and the triangular stress diagram, although for more than two centuries it has been known that these assumptions cannot be supported by theory. Practical calculations on such a basis are facilitated by a multitude of tabulations and charts (e.g., 66–68). To eliminate anomalies inherent in the afore-mentioned assumptions, various approximate methods have been developed.

Kötter's results (69) have made it possible to advance theoretical research by deriving the relation between the shape of the slip plane and the stress acting on it; its equation has been generalized by Jáky (70) for cohesive soils. This result, however, has been used to a relatively slight extent; practical, simpler methods have spread more, such as assuming beforehand the shape of the slip surface (circle, cycloid, logarithmic, spiral).

With the development of the theory of elasticity, more and more general theories have arisen for the analysis of the limit equilibrium of plastic earth bodies. Thus, Sokolovskiĭ (71) elaborated a general method for solving the differential equation of the equilibrium by the general solution of the Kötter equation. Supposing that the entire mass exerting pressure has reached the plastic state, as in the case of a multitude of slip planes; this yields the perfect solution of numerous stability problems for ideal cohesive soil ($\Phi = 0$), ideal granular soil ($c = 0$), and for the general case ($\Phi \neq 0$, $c \neq 0$). Relative to the strength of cohesive soil, the most general definition is applied: the shear stress is a nonlinear function of the normal stress acting on the slip plane. When more empirical data are available relative to the relation between tangential and normal stress components acting on slip planes, the excellent calculational procedure elaborated by Sokolovskiĭ will be of very great value.

Theories relative to perfectly plastic earth masses (41) have been somewhat overshadowed recently, because the assumption $\Phi = 0$ is only justified if total stresses are considered; according

to more recent opinion, it is more nearly correct to consider effective and neutral stresses separately.

A special plasticity theory is the so-called limit analysis (72, 73), according to which the actual value of earth pressure is within a given range, and the lower and the upper limit of this range can be determined by the analysis of the statically and kinematically possible stress fields.

Theories making use of the theory of elasticity are not lacking, either (74); however, these are forced to make far-flung simplifications, and even then their results are still too complicated for practical use.

Since 1936, by reason of Terzaghi's experiments, the literature has given more and more attention to the relation between retaining wall movements and stresses (75, 76). The analysis of different movements has pointed to the possibility of a unique slip plane in which the condition of failure is satisfied only along a single surface that separates two such zones where failure has not yet been reached. Nevertheless, little research has yet been done to determine for different wall movements the geometrically, kinematically, and statically possible slip surface; herein we are still facing considerable development in the theoretical field.

In the author's opinion, analysis of the minimum work performed by the retaining wall and the joining earth masses will lead to development in this field by determining the equation of the slip surface and also of the complete stress state as functions of dislocations. The indefiniteness of the boundary conditions presents difficulties. One of the most successful attempts, free from contradictions and including consideration of the retaining wall movement and with a unique slip plane, dates from 1953 when Brinch Hansen (77) combined the methods of equilibrium and of limit value procedures. By use of the Kötter equation a boundary condition is specified for the top of the slip plane so that the two methods give identical results. A general method is thus given for the treatment of two-dimensional earth-pressure problems.

There are still contradictions in determining the earth pressure occurring in the case of a loaded surface (78–82); methods suggested more or less infringe on basic laws and may be considered as practical approximations only. The author expects results in this domain from large-scale field experiments.

Apart from the problem of soil pressure, there are very few dependable theoretical and practical results known in the field of three-dimensional earth-pressure problems. The most complete theory has been given by Berezantsev (83); other theories available are only approximations. A difficulty here is that pressure on wing walls and pits depends very much on the methods of construction. Széchy (84) gives methods for determining the earth pressure acting on bridge abutments. Pressures on underground conduits are dealt with in fullest extent by Spangler (85).

6 SHEET PILING

The problem of stresses acting on sheet piles has advanced very much during more recent years, especially on the basis of results of large-scale model tests (86, 87). The problem of free sheet piles is sufficiently clear; a fixed-in state may be assumed (67, 88).

The effect of arching behind anchored bulkheads reduces bending moments; this condition may be accounted for by modification of the stress diagram or by introduction of a reduction factor; in most cases, however, this is not warranted, for recently it has been demonstrated that this effect is subject to counteraction by slight anchor movements or shaking. In cohesive soil, there is no such effect at all; therefore, it is often held that the distribution of the active pressure on the back of the wall is calculable according to the Rankine state of active pressure (89, 90), with the effect that in cohesive soil there is no free height that does not transmit pressure (87). The triangular distribution of the total passive pressure may be made use of only if piles are driven to slight depth, at direction angle $\delta = 0$; in case of a fixed-in state, $\delta = \Phi$ may be reckoned with, but a fixed-in state can occur only for certain soil conditions and for certain flexibility of the wall. In the latter case, moments computed for the free-earth-support case may be reduced as functions of the flexibility coefficient (90). This is the first serious suggestion that the flexibility of the wall be taken into consideration; practical application of former proposals has encountered great difficulties. In the dispute between protagonists of the fixed-earth-support and the free-earth-support methods, the scale is turning in the latter's favor, with consideration of the moment reduction. It is, however, still questionable whether the moment reduction is justified in cohesive soil.

7 STABILITY OF EARTH SLOPES

The application of the methods based on the investigation of the most dangerous circular slip line is, at present, routine engineering design practice. In simpler cases, there are ready-made graphs available (4); more complicated problems can be dealt with by the method of slices. There exist different assumptions regarding the distribution of stresses on the slip plane (4). Developments of this method are procedures which consider the pore water pressure (91) and additional stresses caused by water flow. Some recent authors doubt the existence of slip surfaces (92) and see as the cause of failure a certain degree of change of angle. A good synthesis and criticism of modern methods are given by Fröhlich (93).

Fissured clays still present an unsolved problem. In the investigation of the equilibrium of natural slopes, geology still plays an important part; a combined soil-mechanical and geological aspect is described by Terzaghi (94). The stress condition of embankments is best defined by the theory of elasticity (95).

Problems of progressive failure and of slow deformation still call for scientific approach. There are tests indicating that failure occurring in the inside of an earth mass depends on plastic strain (96).

8 GROUNDWATER FLOW

Joint application of geology and of soil mechanics is characteristic of the treatment of problems connected with groundwater, too. Polubarinova-Kochina (97) and Skaballanovich (98) present the best examples of synthesis of the stepwise approach to the treatment of actually occurring complex cases; e.g., depression development in layered soils, discharge of incomplete wells, and the case of anisotropic soils.

In regard to the problem of mutual soil and water effect, it has been pointed out that the suction effect of the soil is more suitable for investigation in connection with mechanical properties. A perfect treatment of these problems is given by Croney and others (99, 100). Practical use of these recent results is soon to be expected. The investigation of the permeability of soils not entirely saturated with water is in great vogue theoretically as well as experimentally (101, 102). Although primary emphasis has been from the point of view of oil mining, the results will be important for foundation work and highway construction as well.

In contrast is the mechanics of frozen soils; its complete treatment, given by Tsitovich (103), is on the basis of the theoretical and experimental investigation of the four-phase, or soil grain-water-ice-air, system. An important result is that, at any negative temperature a liquid phase remains in the soil, the quantity of which varies under the influence of the change of external temperature, pressure, and other effects.

The processes are best described by Tsitovich's equilibriums equation (104). The frost action in soils, as related to highway problems, is best dealt with in (105). The investigation of frozen soils is of great importance in foundation work accomplished with the freezing method (106).

9 DESIGN OF PAVEMENTS AND THE SOIL MECHANICS OF HIGHWAY CONSTRUCTION

Soil mechanics should be credited with raising the design of pavements from among engineering works dealt with purely empirically on the strength of routine or traditions, and with opening the way to the mechanics-mathematical treatment of the problem. For flexible pavements, the procedure known as the "CBR" method appears most dependable (107); for rigid pavements, the Westergaard theory modified by Teller and Sutherland (108) appears best. They are founded partly on an empirical basis; strength characteristics of subsoil and subgrade are determined by shear test or loading test, and the values obtained are used in theoretical formulas verified by practice.

From a theoretical point of view, the elasticity analysis of the stressed state of the two or three-layered system has been a great advance (109–112). Its first application (109) made use of deformations to control the pavement. According to the author's opinion, however, it is more nearly correct to make use of stresses and —with knowledge of the moduli of elasticity of the subgrade and of the pavement, which are by all means to be determined by repeated loading tests—to calculate the pavement thickness on the basis that the Mohr stress circle characterizing the combined stress state produced in the base plane be tangent to a straight line drawn as the envelope of the Mohr circles which are drawn on the basis of linear sections of the strain curves (113). For general application of this method, however, extensive laboratory and field tests on the behavior of soil and pavement and local experience are still necessary.

10 VIBRATIONS AND SOIL DYNAMICS

There are two universal methods for the numerical investigation of foundations for vibrating machinery: One, Rausch's method (114, 46), operates with static weights substituted; the other, Barkan's (115, 12), fixes the permissible value of computed amplitudes. Though there is no substantial difference between their basic theories—both suppose the soil to be a unique vibrating mass executing linear vibrations, the dynamic properties of which are qualifiable by a single physical characteristic, namely, the dynamic coefficient of subgrade—Barkan's method is more logical because it stops at the calculation of the amplitude and compares it to empirical data; it does not examine the foundation on the basis of the permissibility of the soil stress, computed by taking into consideration the substituted static weight. A weak point of both methods is the determination of the coefficient of subgrade and of the natural vibration frequency. In this field, researches of Tschebotarioff and Ward have produced reassuring results (5, 116). Small model tests are not practicable in this field. Most promising is the application of the theory of nonlinear vibrations in this field, which has already explained many confusing phenomena (46, 117).

CONCLUSION

The present task of soil mechanics research is seen to be primarily not in the refinement of theoretical methods nor in the development of laboratory experiments. Basic research on which soil mechanical and foundation engineering design and construction have been built up was practically completed years ago, but the practical application of the theoretical knowledge is still in the empirical stage.

More and more precise and sharp observation of actual conditions, the gathering and systematization of experience, comparison of different soils under actual field conditions, and large-scale field experiments will yield the basis from which a fresh theoretical approach may start, and upon which the solution of the problem (which for the time being appears hopeless) of the uniform theory of strength of anisotropic dispersed masses, with consideration of the mutual physical and chemical effect of soil components and its variation in time, may be constructed. The new theory will avail itself in many respects of the results of geology, with consideration of the conditions of soil strength on the basis of mathematical statistics.

As regards still further development, the author is of the opinion that, in time, soil mechanics will cease to be a separate science in a certain sense; that is, portions of its application will be developed within the corresponding special engineering sciences as one of their organic parts. Soil physics will take its place among the general studies of material testing, and the statics and theory of strength of dispersed systems will become a chapter of theoretical mechanics, just as in the cases of hydraulics or aerodynamics.

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BENSINGER, W.-D., Die Steuerung des Gaswechsels in schnellaufenden Verbrennungsmotoren. Konstruktion und Berechnung der Steuerelemente (Konstruktionensbücher, Bd. 16), Berlin, Springer-Verlag, 1955, v + 93 pp., 106 figs. DM 12.

CODDINGTON, E. A., AND LEVINSON, N., Theory of ordinary differential equations, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1955, xii + 429 pp. $8.50.

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KOLOUŠEK, V., Baudynamik der Durchlaufträger und Rahmen (translated from Czech by Mühl, W.), Leipzig, Fachbuchverlag GmbH, 1953, 217 pp., 64 figs.

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LICHTWITZ, O., Wechselräderberechnung (Werkstattkniffe no. 20), München, Carl Hanser Verlag, 1955, 111 pp., 19 figs. 5.80 DM (paperbound).

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Theoretical and Experimental Methods

(See also Revs. 2612, 2628, 2633, 2635, 2645, 2674, 2686, 2689, 2771, 2782, 2783, 2784, 2786, 2797, 2809, 2893, 2898, 2925)

2590. Loève, M., Probability theory. Foundations. Random sequences (University series in higher mathematics), Toronto, New York, London, D. Van Nostrand Co., Inc., 1955, xv + 515 pp. $12.

This is a rigorous book on probability written by one of the leaders in the field. The coverage of topics, while naturally reflecting the author's special interests, is wide. A great deal of attention is given to the work of the French school of probabilists, particularly that of Paul Lévy and his collaborators. Also, considerable space is devoted to the work of Doob, Feller, Khintchine, and Kolmogorov.

Book is so comprehensive that it is not feasible to list all the topics treated. A great deal of space is devoted to developing probability theory from the measure theoretic point of view, to questions involving sums of independent and dependent random variables and associated limit properties. Author closes with a treatment of conditional distributions, ergodic theory, and random functions of second order.

The book is aimed primarily at specialists in probability and requires a high level of mathematical sophistication on the part of the reader. Much of the book should be of great interest to theoretical physicists and to engineers working with stochastic processes. This is particularly true of the material in the last two chapters.

Author is to be commended for making available to the scientific world such a wealth of results in an important field.

B. Epstein, USA

2591. Schmidt, H., Introduction to vector and tensor calculus [Einführung in die Vektor- und Tensorrechnung] (revised by Kaiser, H.), Berlin, VEB Verlag Technik, 1953, 116 pp.

Contents: I. Vector algebra: real and complex numbers, vectors and vector equations, scalar multiplication, transformation of coordinates, vector multiplication, compound products; II. Vector calculus: vectors as functions of a real variable, vectorial kinematics of particles, physical fields, repeated integrals and integral formulas, fundamental differential operations of vector analysis, hydrodynamic illustration, basic features of the Nabla-operator, integration of vector functions, determination of a source-free vector field by means of its rotation, hydrodynanic applications; III. Fundamentals of elementary tensor methods: concept of stress expressed as a tensor quantity, tensors as vectors and matrixes, products of tensors and vectors, symmetrical tensors.

This is an elementary, clear, and concise textbook for undergraduate engineers about to embark upon a study of these branches of mathematics with special reference to their physical significance. Kaiser's revision differs from the 1935 edition only in a few minor details.

S. Kirkby, England

2592. Berger, E. R., Tensor surfaces, tensor ellipse, and tensor circle (in German), *Öst. Ing.-Arch.* **8**, 4, 231–236, 1954.

Following Lagally ["Vektorrechnung," 1928], first a concise description of the four possible representations of a three-dimensional tensor by means of surfaces (ellipsoids) is given. Then it is shown that for the two-dimensional tensor (ellipses) some of the distinctive features of the four representations are wiped out. Furthermore, it is shown how the two types of circles (Culmann-Mohr, Mohr-Land) may be produced kinematically by the same mechanisms that may produce the ellipses.

K. Klotter, USA

2593. Langefors, B., Ill-conditioned matrices, *SAAB Aircr. Co. Linköping, TN* **22**, 18 pp., 1953.

Author approaches the study of errors occurring in the solution of systems of equations by simple two-dimensional geometric pictures. These guides are afterward complemented by n-dimensional algebraic proofs. The conclusions are illustrated by reference to the approximate inversion of ill-conditioned matrixes. Practical applications are given to the study of a simple horizontal beam with one end fixed and to the analysis of redundant structures. The errors found on a-c analog computers are also discussed.

G. Kron, USA

2594. Kline, M., Asymptotic solution of linear hyperbolic partial differential equations, *J. rational Mech. Analysis* **3**, 3, 315–342, May 1954.

A nonhomogeneous linear hyberbolic partial differential equation $L(u) \equiv \sum_{i,j=1}^{n} a^{i,j} u_{i,j} + \sum_{k=1}^{n} b^k u_k + cu = f_{tt}$ is considered. Independent variables are $x_1, x_2, \ldots, x_{n-1}, x_n = t$, $u_i = \partial u/\partial x_i$, $u_{i,j} = \partial^2 u/\partial x_i \partial x_j$, the coefficients $a^{i,j}$, b^k, and c are functions of $x_1, \ldots, x_{n-1}, f(x, t) = g(x) \cdot h(t)$, where x stands for $x_1, \ldots, x_{n-1}$. Omitting here the details with respect to the required conditions, this equation is solved by a Duhamel integral

$$u(x, t) = {}_0\int^t U(x, t - \tau)h(\tau)d\tau, \qquad t \geqq 0$$

where $U(x, t)$ is the solution of $L(u) = g(x)\delta'(t)$, $\delta(t)$ being the Dirac delta function. From this an asymptotic series is obtained for large t if $h(t) = e^{-i\omega t}$, with $1/\omega$ as its basic variable. Special care is required for the discontinuities in $U(x, t)$ with respect to t. The rest of the paper is devoted mainly to the investigation of these discontinuities which fulfill a recursive system of first-order linear ordinary differential equations. Finally, the relation to the W. K. B. method is pointed out.

A. van Heemert, Holland

2595. Ladyzhenskaya, O. A., Solvability of basic boundary-value problems for equations of the parabolic and hyperbolic types (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **97**, 3, 395–398, July 1954.

Author deals in the paper with two problems:

(1) To solve parabolic equation

$$u_t = \sum_{i,j=1}^{n} a_{ij}(\partial^2 u/\partial x_i \partial x_j) + \sum_{i=1}^{n} b_i \partial u/\partial x_i + cu + f$$

in a region Q. Initial condition: $u|_{t=0} = 0$. Boundary condition $u|_\Gamma = 0$ or Newton's condition

$$\sum_{i,j=1}^{n} a_{ij}(\partial u/\partial x_i) \cos(n, x_j) + \sigma u|_\Gamma = 0$$

(2) To solve hyperbolic equation

$$u_{tt} = \sum_{i,j=1}^{n} a_{ij}(\partial^2 u/\partial x_i \partial_j) + \sum_{i=1}^{n} b_i(\partial u/\partial x_i) + cu + f$$

with initial conditions $u|_{t=0} = 0$, $u_t|_{t=0} = 0$.

Using some functional analytical facts, existence and uniqueness theorems of both the problems are proved for any function f from the space $L_2(Q)$. The solution is understood in a generalized (Sobolev's) meaning. (For questions of generalized solutions, generalized derivatives, etc., see, for example, Michlin, "Minimum of quadratic functional"; Sobolev, "Applications of functional analysis in theoretical physics.")

K. Rektorys, Czechoslovakia

2596. Birman, M. Sh., Spectrum of singular boundary-value problems for elliptic differential equations (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **97**, 1, 5–7, July 1954.

K. Friedrichs [*Math. Ann.* **109**, 685, 1934] has, by operational methods, studied Schroedinger's wave equation for a particle moving in the unbounded space with the scalar potential v, where v may have a certain singularity in the origin and may have the lower limit 1 at infinity. Then, the spectrum is discrete between $-\infty$ and 1.

Author generalizes Friedrich's results by replacing the Laplace operator by a more general one and by introducing a boundary surface Γ with mixed boundary conditions on it and considering the exterior or interior. Then, Friedrich's results hold true and, moreover, the continuous part of the spectrum is unaffected by a change of Γ or the conditions on it. As far as proofs are given, they rely upon the fact that complete continuous operators have only discrete eigenvalues and proceed in establishing this quality for certain differences.

G. Plato, Germany

2597. Kreĭn, M. G., Integral equations generating differential equations of the second order (in Russian), *Dokaldi Akad. Nauk SSSR (N.S.)* **97**, 1, 21–24, July 1954.

Author shows that, starting from a set of integral equations of Fredholm type with known solutions, there exists an ordinary linear differential equation with equal (or constant) first and third coefficients for which the initial value problem can be explicitly solved. Another similar theorem is given in the paper's second part. Here suitable kernels can be gained as solutions of a certain partial differential equation.

However, the range of practically important cases accessible to one of these procedures seems to be rather narrow.

G. Plato, Germany

2598. Koiter, W. T., Approximate solution of Wiener-Hopf type integral equations with applications. Part I, General theory, *Proc. k. Ned. Akad. Wet. (B)* **57**, 5, 558–564, Nov./Dec. 1954.

Various physical and engineering problems can be reduced to an integral equation of the form

$${}_0\int^\infty m(\xi)h(x - \xi)d\xi = \varphi(x)$$

The exact solution by the Wiener-Hopf method [E. C. Titchmarsh, "Theory of Fourier integrals," Oxford, 1937, 339–342] is often very difficult. The method developed by the author consists in approximating the Fourier transform $H(w)$ of the kernel $h(x)$ by a simpler function $H^*(w)$, so that the Wiener-Hopf method applied to $H^*(w)$ becomes numerically feasible.

A mathematical justification of the approximative method by a perturbation analysis is given.

W. Noll, Germany

2599. **Koiter, W. T., Approximate solution of Wiener-Hopf type integral equations with applications. Part IIA, Some plate bending problems and an example from hydrodynamics,** *Proc. k. Ned. Akad. Wet.* (*B*) **57**, 5, 565–574, Nov./Dec. 1954.

2600. **Koiter, W. T., Approximate solution of Wiener-Hopf type integral equations with applications. Part IIB, Some plate bending problems and an example from hydrodyamics,** *Proc. k Ned. Akad. Wet.* (*B*) **57**, 5, 575–579, Nov./Dec. 1954.

Author applies the method described in the preceding review to the following examples: (1) Infinite plate strip simply supported or clamped along one edge and partly simply supported and partly clamped along the other edge; (2) slow steady flow of a viscous fluid between two infinite and one semi-infinite parallel plates. Two approximations for each problem are considered, one requiring little, the other moderate, numerical work. The last part of the paper is concerned with an example which is formally similar to the ones just mentioned and for which the exact solution can be given explicitly. This example is used to compare the exact solution with the approximations.

W. Noll, Germany

2601. **Lotkin, M., The solution by iteration of nonlinear integral equations,** *J. Math. Phys.* **33**, 4, 346–355, Jan. 1955.

A formal proof is given that solutions of a certain generalized integral equation involving a kernel and repeated integration can be obtained by an iterative procedure. Such equations occur in the treatment of certain wave phenomena and in other physical contexts. A special case is discussed in which the kernel can be expressed as a bilinear form, and a numerical example is given of a more general case. The paper is mathematical in style, but it is pointed out that the methods are eminently suitable for use with a digital computer. M. V. Wilkes, England

2602. **Gavurin, M. K., Accuracy of methods of approximation for the finding of characteristic numbers of integral operators** (in Russian), *Dokladi Akad. Nauk SSSR* (*N.S.*) **97**, 1, 13–15, July 1954.

Method consists in approximating the not necessarily symmetrical kernel K by a kernel of product type K_0 of finite order n, for which computing the eigenvalues amounts to solving an algebraic equation of order n.

For simple eigenvalues, author had given an upper bound of the error involved in an earlier paper [*Dokladi Akad. Nauk SSSR* (*N.S.*) **96**, no. 6, 1954]. He presupposed a condition to be satisfied by the difference of the two kernels and quantities depending only upon K_0.

Present paper is concerned with estimating these quantities.

Practicability of the results depends upon finding a convenient K_0 and the accuracy requirements (n not too large).

G. Plato, Germany

2603. **Lonseth, A. T., Approximate solutions of Fredholm-type integral equations,** *Bull. Amer. math. Soc.* **60**, 415–430, 1954.

Paper is concerned with the equation

$$x(s) - {}_0\int^1 K(s, t)x(t)dt = y(s)$$

and with the eigenvalue problem $x(s) - \lambda\, {}_0\int^1 K(s, t)x(t)dt = 0$, $0 \leqq s \leqq 1$. After some historical remarks a short survey of known numerical methods is presented. Hitherto obtained results on error bounds are discussed for the following three methods: (1) substitution of $K(s, t)$ by another kernel, usually of finite rank; (2) approximation of $x(s)$ by a linear combination of given functions and determination of the coefficients by a minimum principle; (3) iterative methods. The functions $x(s)$ and their errors are considered in a normed linear space, and the norm is either $||x|| = \max_s |x(s)|$ or more generally $||x|| = ({}_0\int^1 |x(s)|^p ds)^{1/p}$, $p \geqq 1$, especially with $p = 2$. The error bounds under discussion are bounds for the norm of the error related to the evaluation of $x(s)$. The paper mentions results of about 25 authors and includes some numerical illustrations.

H. Bückner, USA

2604. **Rothman, M., Tables of the integrals and differential coefficients of $Gi(+x)$ and $Hi(-x)$,** *Quart. J. Mech. appl. Math.* **7**, part 3, 379–384, Sept. 1954.

2605. **Salzer, H. E., A simple method for summing certain slowly convergent series,** *J. Math. Phys.* **33**, 4, 356–359, Jan. 1955.

2606. **Maehly, H. J., An iterative approximation of the roots of an algebraic equation** (in German), *ZAMP* **5**, 3, 260–263, 1954.

The slow convergence of Newton's method for the iterative approximation of the roots of an algebraic equation may be improved by using a formula due to Laguerre. It is shown that this formula together with certain generalizations is useful for the numerical calculation of both real and complex zeros. A method is also given for the calculation of a further root of an equation after several roots have already been found, such that errors on the determination of the previous roots will not affect the accuracy with which the present one may be approximated.

From author's summary

2607. **Horvay, G., and Born, J. S., Tables of self-equilibrating functions,** *J. Math. Phys.* **33**, 4, 360–373, Jan. 1955.

2608. **Seay, P. A., New circuit computes tangents,** *Control Engng.* **1**, 3, 59–60, Nov. 1954.

2609. **Davis, S. A., 31 ways to multiply. How to pick them. How to use them,** *Control Engng.* **1**, 3, 36–46, Nov. 1954.

A roundup of important analog multipliers—mechanical, electromechanical, and electronic. From author's summary

2610. **Fite, W. L., Maximization of return from limited resources,** *J. Soc. indust. appl. Math.* **1**, 2, 73–90, Dec. 1953.

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 2640, 2645, 2675, 2728, 2740, 2826, 2834, 2842, 2870, 2914)

2611. **Holowenko, A. R., Dynamics of machinery,** New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1955, vii + 464 pp. $7.50.

Book is designed as a text for machine-design courses devoted to kinematics and force analysis for engineering students in their third and fourth years in American universities.

Text contains twenty-two chapters of greatly differing length. The first nine chapters, comprising somewhat less than one third of the book, deal essentially with velocities and accelerations in simple mechanisms. The following six chapters are devoted to equivalent mechanisms, static forces, graphic statics, inertia forces, and dynamic analysis. The next five chapters, again comprising about one third of the book, deal fairly completely with problems of flywheels and balancing of reciprocating masses. The final two chapters deal with vibrations in shafts and gyroscopes, respectively.

Apparently the author, and the publisher, feel that there is sufficient need for a textbook on this subject to justify their efforts; consequently, the book should be judged according to the aims and objectives of the author. It is indeed unfortunate that the author, in his preface, has neglected to state exactly what his objectives are, other than to present a textbook built upon his teaching of a specific set of courses. As to the actual methods of presentation of the material, however, the author has stated his goals quite completely and, in the opinion of the reviewer, has met them in an admirable way. The book makes excellent use of free-body diagrams, and very frequently more than one method of analysis is discussed (both analytical and graphical methods are used and compared). Over three-hundred problems are given for student solution and, on the whole, appear to be rather good. The book has a pleasing format and appearance; the illustrations are exceptionally well done.

Author claims that "a departure from the usual textbook presentation has been made"; the reviewer was able to detect no major departure.

Those institutions desiring to adopt a new text for certain machine-design courses should give this volume very careful consideration; it appears to be a better-than-average text.

H. N. Abramson, USA

2612. Gran Olsson, R., On the analogy of some problems of dynamics of mass points and rigid bodies, I, *Norske Vid. Selsk. Förh. Trondheim* **27,** 4, 8 pp., 1954.

The spherical pendulum and the two-body problem are treated by means of the Hamilton-Jacobi equations. Only elementary and well-known results are obtained, the purpose being to provide analogies for comparison with results to appear in a later paper on the nonholonomic motion of a sleigh. H. D. Block, USA

2613. Vernic, R., Periodic solutions of the three-body problem (in German, with Croatian summary), *Glas. Mat.-Fiz. Astr.* (2) **8,** 4, 247–266, 1953.

Author states the theorem: The only periodic solutions of the general three-body problem are those of Lagrange. The proof is not everywhere clear to the reviewer. Author himself is aware of the fact that his result is in contradiction to the opinion, based on Poincaré's work, of most mathematicians and astronomers.

O. Bottema, Holland

2614. Wolski, K., Determination of the acceleration of a rigid body in plane movement (in Polish, with French summary), *Arch. Mech. stos.* **5,** 291–294, 1953.

If the fixed point of a solid moves away indefinitely in a direction perpendicular to a plane Π, the angular velocity and acceleration vectors tend toward two line vectors perpendicular to Π and going, respectively, through the velocity and acceleration centers of the limit plane motion of Π.

A. W. Wundheiler, USA

2615. Arzhanikh, I. S., On the equations of rotation of a heavy rigid body about a fixed point (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **97,** 403–406, 1954.

The intention of this paper can be understood if most of all nonsymbolic context is ignored, and the meaning of some symbols guessed (against the context). Because the angle of procession is a cyclic coordinate, there exists a system of equations in θ and ϕ involving also the precession constant. The cosines of the vertical α, β, γ are dependent functions of θ and ϕ, and there exist infinitely many linearly independent systems of equations of second order in α, β, γ. Of these, author (Theorem I) derives one of repulsive complexity, with needless changes of variables and misleading notations. Theorem II expresses α, β, γ in terms of Jacobi's elliptic functions of two independent variables u, v, and introduces two new variables x and y

$$(dx/du)^2 = A\ \mathrm{sn}^2\ u + B\ \mathrm{cn}^2\ u, \quad (dy/du)^2 = A\ \mathrm{sn}^2\ v + \mathrm{cn}^2\ v$$

Now the equations of motion become

$$x'' = V_x = fWy', \quad y'' = V_y + fWx'$$

where V and W are two functions of u, v, much too complicated to be reproduced here, and the primes indicate some undefined differentiation, not easy to guess at. Theorem III draws on a previous paper of the author claiming that the equations quoted have a linear integral, and hence that there is a "new" integral in gyration theory. The integral is not stated, nor is it said in which variables the integral is linear. A. W. Wundheiler, USA

2616. Melzer, M., Contribution to the theory of tail-wheel shimmy, *NACA TM* 1380, 37 pp., Dec. 1954. (Translation from Focke-Wulf Flugzeugbau GmbH., Bremen, *Technische Ber.* 7, no. 2, 1940.)

A basic theoretical and experimental investigation is made of the shimmy behavior of a swiveling landing gear, the experimental tests being conducted with a small wheel mounted over a continuous belt. Effects of wheel loading, rolling velocity, rearward position of the wheel with respect to the swivel axis, tire elasticity, and torsional flexibility of the fuselage are investigated both experimentally and theoretically. A major theoretical conclusion is that the motion of a landing gear moving in a straight line without fuselage elasticity is stable for a sufficiently large rearward position of the wheel behind the swivel axis, and this conclusion is well verified quantitatively by the experimental data.

From author's summary

2617. Morelli, A., Comparison of the forced sway of vehicles with different suspensions (in Italian), *ATA* **6,** 427–430, Aug. 1953.

A comparison is made of forced sway (with damping) of two types of motor-vehicle suspension: one with variable flexibility and one with constant flexibility. These curves have been obtained by the adoption of an electronic analog calculating machine for the differential equations involved in the movement of masses, suspended and nonsuspended.

Beside the advantages in its statical behavior, the advantages of the variable flexibility type are evidenced also in the dynamical performance. From author's summary

2618. Niven, C. D., On the friction of rubber covered wheels on ice, *Canad. J. Technol.* **33,** 3, 204–210, May 1955.

The friction between a small rubber-covered wheel and ice was examined. Amontons' linear relation between load and frictional

force was found to hold at 20 F and lower. There was a distinct indication that on wet ice soft rubber gripped better than harder rubber. However, on wet ice and on ice just below the freezing temperature, friction was so low that the squeezing down of the rubber under load vitiated results. The work suggested that a pneumatic tire must be used as a test sample if road conditions are to be duplicated. From author's summary

2619. Padfield, D. G., A note on friction between yarn and package, *J. Text. Inst. Trans.* **46,** 2, T71–T77, Feb. 1955.

A simple relation between yarn-package coefficient of friction and easily measurable quantities is derived. The formula is applied to measurements made on two yarns, and the resulting information is presented graphically.

From author's summary

2620. Duncan, W. J., Projective relations in plane kinematics, *Quart. J. Mech. appl. Math.* **7,** 352–356, 1954.

It is shown that if n coplanar bodies have relative motion, then the set of instantaneous centers of rotation is a linear configuration which, therefore, is preserved under projective transformations of the motions. For $n = 3$, the centers are collinear. For $n = 4$, the lines and distances illustrate the theorem of Menelaus. For $n = 5$, Desargues' theorem is illustrated. Extension to motions over a spherical surface is indicated.

M. Goldberg, USA

Servomechanisms, Governors, Gyroscopics

(See also Revs. 2609, 2801, 2828, 2846)

2621. Moreau, R., Semi-theoretical calculation of a positional servomechanism (in French), *Rech. aéro.* no. 40, 27–31, July/Aug. 1954.

Author proposes a step-by-step method for the design of a servomechanism. Although this technique is not optimum in a rigorous mathematical sense, it is claimed to be efficient in an engineering sense. The ideas behind this scheme were motivated by the papers of Wiener, Pellegrin, and Phillips. In particular, the notions of input signals being defined by the spectra of their autocorrelation functions and of optimum performance being obtained when the mean square error is a minimum are retained.

Let $\rho(f)$, f being the frequency, be the transfer function of the open-loop servo and $G(f)$ be the spectra of the input function. Let f_0 be a frequency about which $G(f)$ can be considered to be negligible in an engineering sense. A preliminary design of the servomechanism is now made, having an open-loop cut-off frequency of f_0, i.e., $\rho(f_0) = 1$. The design is then tested for stability, either mathematically or experimentally, by constructing a Nyquist diagram. This is followed by taking a recording of the servo error voltage and its mean square value determined. If the error is sufficiently small, the design is considered complete. If not, then alterations are made in the design to improve its error performance and the process repeated.

It is claimed by the author that this procedure is both economical and rapid, even though it does not yield a true optimum design. He calls the condition $\rho(f_0) = 1$, "a condition of economic error." H. M. Trent, USA

2622. Chelomei, V. N., On pneumatic servomechanisms, *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 5, 39–50, 1954. (Translation by M. D. Friedman, 2 Pine St., W. Concord, Mass.)

Differential equations are derived and important parameters identified for a rudder-positioning servomechanism. Conditions under which the equations may be linearized are discussed. Without sufficient damping the linear system is found to be unstable.

Reviewer believes the analysis is clear and complete as to linear, nonnumerical methods and the translation unusually readable and accurate. C. M. Ablow, USA

2623. Lee, S.-Y., Contributions to hydraulic control—6, *Trans. ASME* **76,** 6, 905–911, Aug. 1954.

See AMR **7,** Rev. 2081.

2624. Paddison, F. C., and Good, W. A., A method for the selection of valves and power pistons in hydraulic servos, ASME Spring Meet., Baltimore, Md., Apr. 18–21, 1955. Pap. 55—S-10, 15 pp.

An analysis was made of hydraulic servo systems to determine a method of selecting transfer valves and power pistons that will give the optimum oil-pressure distribution within a servo. Two valve types were considered: (1) Those in which the oil flow is independent (or nearly so) of the reaction (Bernoulli) forces within the valve; in this type the rate of oil flow is a function of the pressure across the valve. (2) Those in which the oil flow is not independent of the reaction forces. The valve may use these forces to effect a compensation such that the oil flow rate is reasonably independent of the pressure across the valve.

It was found that a valve should provide the required power-piston speed at full load with a valve pressure drop of one third the supply pressure. Correspondingly, the power-piston area should be selected with a pressure drop of two thirds the supply pressure assumed across the piston. The efficiency of such a servo is 66%. A valve pressure drop of less than one third the supply pressure may reduce oil consumption if flow limiters are used, but such a choice may result in increased overlap and dead-space difficulties, since it allows a large gain change between the full-load and no-load conditions. A valve pressure drop of greater than one third the supply pressure reduces the gain change between the full-load and no-load conditions, but consumes more oil. A mechanism for gain compensation was also studied, and it was found that the best result is achieved with a design pressure drop across the valve of one third the supply pressure.

From authors' summary

2625. Ikebe, Y., Researches on fluid servo-motor (On some fundamental properties of floating-type hydraulic servo-motor), *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952: Nat. Committee for Theor. appl. Mech., May 1953, 353–357.

2626. Shearer, J. L., Dynamic characteristics of valve-controlled hydraulic servomotors, *Trans. ASME* **76,** 6, 895–903, Aug. 1954.

See AMR **7,** Rev. 2386.

2627. Shearer, J. L., Proportional control of rate-type servomotors, *Trans. ASME* **76,** 6, 889–894, Aug. 1954.

See AMR **7,** Rev. 2387.

2628. Piatt, A., Mechanical analog-computing elements and their applications to automatic control, *Trans. ASME* **76,** 6, 883–888, Aug. 1954.

See AMR **7,** Rev. 2388.

2629. Faber, S., Ground-simulator study of the effects of stick force and displacement on tracking performance, *NACA TN* 3428, 21 pp., Apr. 1955.

Tests were performed on a ground simulator with one degree of freedom, pitch, to determine the desired magnitude of the control-stick forces and displacements in relation to the performance of a tracking task. The dynamics of the simulated airplane were typical of those of current fighters operating at low altitudes and at subsonic speeds and having an undamped natural frequency of $^1/_2$ cps and a damping ratio of approximately 0.8.

From author's summary

2630. Bobier, W. S., Dynamic testing of jet-engine fuel controls using an engine simulator, ASME Ann. Meet., N. Y., Nov. 28–Dec. 3, 1954. Pap. 54—A-136, 11 pp.

2631. Lenox, S., Let's keep it functional: simplified ratio control, *Control Engng.* **1,** 3, 32–34, Nov. 1954.

Automatic treatment of water and sewage does not always demand high precision. Often the ratio of the two flows need be held only within plus-or-minus 5%. In such cases, the cost of elaborate pneumatic or electronic ratio-control equipment is not justified. Article describes the engineering design of simple and inexpensive flow-ratio control systems.

From author's summary

2632. Larrowe, V. L., Direct simulation bypasses mathematics, simplifies analysis, *Control Engng.* **1,** 3, 25–31, Nov. 1954.

Article describes a concept which simplifies simulation. The computer circuit is built from functional blocks, which are direct analogs of components in the system to be simulated.

From author's summary

Vibrations, Balancing

(See also Revs. 2617, 2670, 2768, 2801, 2940, 2941)

2633. Howe, C. E., and Howe, R. M., Application of the electronic differential analyzer to the oscillation of beams, including shear and rotary inertia, *J. appl. Mech.* **22,** 1, 13–19, Mar. 1955.

The differential equations for the transverse vibrations of a beam, including the effects of shear and rotary inertia, were solved on a electronic computer of the analog type. The differential equations were used in their basic form as a coupled system, rather than as a single equation of fourth order. Curves showing the frequencies for the first three normal modes of a uniform free-free beam are presented for a wide range of shear and inertia parameters. 132 different cases are embodied in the presentation. Hints are given for the use of the computer if the beam has nonuniform cross section. No explicit results are reported for this case, however. K. Klotter, USA

2634. Pestel, E., Generalization of the Holzer method for the vibration calculation of shafts (in German), *ZAMM* **34,** 8/9, 320–321, Aug./Sept. 1954.

2635. Okumura, A., On a method for vibration problems of branch-type systems (Note on a general extension of step-by-step method), *Proc. 2nd Japan Nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 323–328.

Author presents a unified matrix analysis of systems of the kind solvable by the Holzer-type methods. He discusses application to free and forced vibrations. Also considered are one-dimensional continuous systems made up of units, each governed by a finite set of continuous differential equations.

A. I. Bellin, USA

2636. Kanazawa, T., and Kawai, T., On the lateral vibration of anisotropic rectangular plates (Studied by the integral equation), *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 333–338.

Through collocation of integral equation, the frequency equations are derived for vibration of uniform anisotropic rectangular plates with each edge either clamped or simply supported. Only the Green function for simply supported plate is used; clamped edges are handled by introducing edge moments of magnitude sufficient to annihilate slope. Calculated values are given for fundamental natural frequencies of square anisotropic plates and rectangular isotropic plates with various combinations of edge conditions. J. M. Hedgepeth, USA

2637. Yamamuro, M., Some vibration problems in connection with helical valve springs, *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952: Nat. Committee for Theor. appl. Mech., May 1953, 315–317.

Author proposes to treat two problems in helical springs which can be treated by considering the progressive waves traveling in the spring during the time which the valve is open.

From author's summary

2638. Sankey, G. O., Plastic models for vibration analysis, *Proc. Soc. exp. Stress Anal.* **11,** 2, 81–90, 1954.

2639. Boschi, A., Dynamical characteristics of rubber in relation to antivibration applications (in Italian), *ATA* **6,** 1, 41–53, Jan. 1953.

Wave Motion in Solids, Impact

(See also Rev. 2716)

2640. Babich, V. M., Solution of Cauchy's problem for a system of equations in the theory of elasticity of nonhomogeneous elastic media (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **96,** 6, 1125–1128, June 1954.

The equation of motion of nonhomogeneous elastic media is expressed as: $-\bar{L}(\bar{u}) + (\partial^2\bar{u}/\partial t^2) = \bar{X}$, where all the coefficients and free terms are sufficiently continuous.

Examination of the generalized functions indicates that by essentially considering the basis of Sobolev's method and Hadamard's method as identical, construction of the fundamental solution is precise for the case of constant coefficients and approximate for the case of variable but sufficiently continuous coefficients. N. M. Matusewicz, USA

2641. Lebedev, N. F., Secondary elastoplastic wave (in Russian), *Prikl. Mat. Mekh.* **18,** 2, 167–180, Mar./Apr. 1954.

The propagation of waves in rods of nonlinear work-hardening material is studied by means of the method of characteristics. It

is shown that, in contrast to an assumption made by H. A. Rahmatulin [AMR **3**, Revs. 1950, 2202], under certain circumstances the velocities of propagation of the primary and of the reflected waves will differ. J. R. M. Radok, Australia

2642. **Cann, G. L., Non-linear waves in solids,** *Proc. 2nd Canadian Symposium on Aerodynamics, Inst. of Aerophysics, Univ. of Toronto,* Feb. 1954, pp. 238–263.

The general one-dimensional conservation laws for plastic flow of a bar are derived in Lagrangian coordinates. The equations of von Kármán [*N.D.R.C. Rep.* A-29] and Malvern [*Brown Univ. Rep.*] are derived as special cases. The three characteristic equations are developed by the procedure of Guderley [*NACA TM* 1196], using logarithmic strain and material stress as variables.

A detailed solution is given for the case of longitudinal impact with constant velocity, assuming work-hardening to be a function of plastic work. Plastic shock waves do not occur traveling at speeds less than that of elastic waves.

F. R. N. Nabarro, South Africa

2643. **Imachi, I., On the lateral mass impact at the end of a very long bar with two flexural rigidities—bending and shearing** (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21**, 103, 216–222, 1955.

An analytical investigation is developed on a problem of lateral mass impacts applied at the end of a semi-infinitely long bar under assumptions similar to the previous report [*Mem. Fac. Engng. Nagoya Univ.* **2**, no. 1, 1950]. The difficulty that occurs when one determines the roots of the characteristic equation (Eq. 10a) has been conquered by application of a statistical treatment. The phenomena subsequent to the impact are discussed and computed, referring mainly to the shearing strains and bending strains. It can be qualitatively explained that the larger the velocity of impact becomes, the nearer approaches the point of failure to the struck end, if the failure is assumed to depend only on the amount of bending stress. From author's summary

2644. **Stoneley, R., Rayleigh waves in a medium with two surface layers. I,** *Monthly Notes roy. astr. Soc. Geophys. Suppl.* 6, 610–615, 1954.

The period equation is obtained in the form of a determinant of the tenth order. If the length of Rayleigh waves propagating in this layered half-space is very small, the determinant reduces to the product of three determinants. They then yield period equations for very short Rayleigh waves along the free surface as well as for similar waves along the two interfaces.

W. S. Jardezky, USA

Elasticity Theory

(See also Revs. 2640, 2644, 2677, 2686, 2697, 2699, 2701, 2703, 2718)

2645. **Biezeno, C. B., and Grammel, R., Engineering dynamics. Vol. 1. Theory of elasticity: Analytical and experimental methods (translated from the German by M. L. Meyer),** London, Glasgow, Blackie & Sons, 1955, viii + 307 pp. 50s.

This book contains the translation of the first portion of the recently published second edition of "Technische Dynamik" [AMR 7, Rev. 694].

The volume at hand, the first of four, is subdivided into three parts. It may be of interest to list, briefly, the various topics treated. Part I, entitled "Fundamental laws of elastomechanics," contains a discussion of stress, strain, stress-strain relations, the field equations, and elastic stability. Part II, headed "General theorems of elastomechanics," contains a discussion of several variational, energy, and reciprocal theorems (Hamilton, Clapeyron, Betti, Castigliano, Maxwell), and of stress functions for plane strain, plane stress, axially symmetric stress, and torsion by terminal couples. Part III, subtitled "Methods of solution," lists solutions of Laplace and biharmonic equations, a discussion of harmonic analysis, numerical methods (Ritz, Galerkin, and their generalizations, finite differences, etc.), and of various experimental methods of determining stress and strain (strain gage, soap bubble, electrical, optical).

The translator has done his job well; the printing, paper, and binding are of high quality. There is little doubt that the publication of this English version will enable many more workers in the field to become familiar with one of the famous books in the literature of mechanics. H. Deresiewicz, USA

2646. **Timoshenko, S., Stress concentration in the history of strength of materials,** *Proc. Soc. exp. Stress Anal.* **12**, 1, 1–12, 1954.

2647. **Varvak, P. M., A method of approximate solution of spatial problems of the theory of elasticity** (in Ukranian, with Russian summary), *Dopovidi Akad. Nauk Ukrain. RSR* **1953**, 285–288, 1953.

In the solution of three-dimensional problems of elasticity by use of the Galerkin method, it is suggested that the biharmonic equation for the Galerkin function and the representations of the components of stress in terms of the derivatives of the Galerkin function be replaced by difference equations on a discrete point-lattice. Boundary conditions are discussed and it is noted that the role of the stress function in these equations is independent of the loading and hence the derived figures of influence for a given body can be used for all loadings. C. Saltzer, USA

2648. **Reissner, H., and Reissner, E., Torsion of a circular cylindrical body by means of tractions exerted upon the cylindrical boundary,** "Studies in mathematics and mechanics" (presented to R. von Mises by Friends, Colleagues, and Pupils), New York, Academic Press, Inc., 262–273, 1954.

An exact Fourier series solution is given for the title problem when the elastic body possesses curvilinear allotropy. The tractions may be distributed either over part or all of the cylindrical boundary. The results reduce to those given earlier by Filon when the body is isotropic. Several approximate solutions are discussed, in which the use of Fourier series is avoided, including a modified beam theory for torsion with distributed loads; the latter is deduced with the aid of a variational theorem due to E. Reissner [AMR **4**, Rev. 2381]. The paper concludes with a solution for the effect of solid core on twisting of circular cylindrical shell.

P. M. Naghdi, USA

2649. **Yu, Y.-Y., Torsion of a semi-infinite body and a large thick plate,** *Quart. J. Mech. appl. Math.* **7**, part 3, 287–298, Sept. 1954.

Author obtains solution for stress and displacement of a semi-infinite body subjected to torsional stresses distributed arbitrarily over a portion of the surface. Also, he obtains a similar solution to a thick plate subjected to torsional loads on the two faces of the

plate. Numerical solution is given for semi-infinite body with torsional stress distributed over a circular area and varying linearly from zero at center of area. Numerical solutions also are given for a concentrated torsional load on both semi-infinite body and thick plate. W. B. Stiles, USA

2650. Green, A. E., A note on second-order effects in the torsion of incompressible cylinders, *Proc. Camb. phil. Soc.* **50,** 488–490, 1954.

Green and Shield [AMR **5,** Rev. 1015] have constructed a general theory of second-order effects in the torsion of an incompressible elastic cylinder of uniform cross section, reducing it to the solution of certain integral equations. Rivlin [AMR **6,** Rev. 2709] has shown how second-order effects in any elastic body may be calculated from the solutions of two appropriate problems in the linear theory. For the torsion problem, the torsion function in the linear theory must thus be known if we are to calculate all the second-order effects. By use of Betti's theorem, however, Rivlin was able to calculate the fractional elongation of a compressible cylinder explicitly in terms of the moment of inertia, the classical torsional rigidity, and the five elastic constants of first and second order. He then obtained the corresponding results for an incompressible cylinder by a limiting process. The author shows that the method of Green and Shield can also yield this explicit result without our having to solve the integral equations. He then generalizes it to the case when the cylinder is stretched before it is twisted. C. Truesdell, USA

2651. Green, A. E., and Spratt, E. B., Second-order effects in the deformation of elastic bodies, *Proc. roy. Soc. Lond.* (*A*) **224,** 347–361, 1954.

Rivlin [AMR **6,** Rev. 2709] has embedded the solution of a boundary-value problem in the linear theory of elasticity as the first approximation in a perturbation procedure for finding a certain (possibly not unique) solution of a corresponding problem in the general theory of finite strain. His method rests upon expansions in powers of the displacement gradients. (In the paper cited, only the second approximation and only the isotropic case are considered, but in the work by Rivlin and Topakoglu [AMR **8,** Rev. 362] the method is formulated in the nth approximation for general elastic materials.) The authors propose an alternative scheme based upon expansions of all quantities in power series in a parameter ϵ. They work out the details for the second-order approximation for isotropic bodies. Their method has an advantage over Rivlin's in that it applies equally to incompressible or compressible bodies, while Rivlin's method applies only to compressible bodies and yields results in the incompressible case only by a limiting process. However, the authors obscure this advantage by describing their procedure in detail separately for the two cases. Their results do not seem to yield Rivlin's elegant reduction of the entire problem to the solution of a finite number of appropriate problems in the linear theory, and the calculations seem formidable. The authors illustrate their method by calculating second-order effects in the torsion of an incompressible solid of revolution, specializing to the case of a cone.

C. Truesdell, USA

2652. Nagai, T., A contribution to determining two-dimensional stresses (On a deep beam having a projected part), *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 61–65.

A two-dimensional analysis of a particular short beam of varying depth is carried out, assuming uniform stresses over the supports. The analysis is made by superposing stresses arrived at by three different methods. The analysis of a beam of uniform depth whose boundaries contain those of the nonuniform beam is made by superposing two sets of stresses. The first is a set of stresses satisfying the stress-function equation $\nabla^4\psi = 0$; the second, a set of stresses which the author states as being found by the principle of least work. No details are given as to the derivation of this second set of stresses. The third set of stresses are found by an approximate "conformal transformation." These stresses when superposed on the first two satisfy the original boundary conditions. No evaluation is made of the accuracy of the approximation.

Three references (one not yet published) are given, although it is not shown to which part of the paper they refer.

A. L. Ross, USA

2653. Leven, M. M., and Frocht, M. M., Stress concentration factors for a single notch in a flat bar in pure and central bending, *Proc. Soc. exp. Stress Anal.* **11,** 2, 179–184, 1954.

See AMR **6,** Rev. 2725.

2654. Segawa, W., An approximate method for solving the stresses of cylindrical rubber in a deformation, *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 37–39.

Experimental Stress Analysis

(See also Revs. 2638, 2646, 2653, 2718, 2719, 2733)

2655. Gallant, R. A., and Benda, E. K., An automatic load control for tuning-fork fatigue test equipment, *GM Engng. J.* **1,** 9, 6–9, Nov./Dec. 1954.

This new fatigue resonant testing machine is of the tuning-fork type and was developed for full-scale testing of crankshaft sections or other machine parts. The test piece forms the cross-over member between two large bars, and the mechanical system is excited in resonant vibration by a motor-driven unbalance. The vibration amplitude is regulated by the speed control of the exciter motor by means of contact, relay, and servomotor. To enlarge the application of the test equipment and to get a high degree of accuracy and stability of operation, authors developed an automatic load control system using strain gages; the complete power and control units are built up in a special control box.

M. Hempel, Germany

2656. Thomsen, E. G., and Lapsley, J. T., Jr., Experimental stress determination within a metal during plastic flow, *Proc. Soc. exp. Stress Anal.* **11,** 2, 59–68, 1954.

Following method is proposed for calculating stresses in plastic zone under conditions of axial symmetry or plane strain: (1) Determine components of strain increment at all points in a typical plane of flow from measured changes in a scribed grid during a stepwise process of deformation. (2) Hence, calculate components of deviatoric stress from assumed Lévy-von Mises relations and some yield criterion. (3) Determine distribution of hydrostatic stress from equations of equilibrium, with help of a measured total load or a local pressure.

Assumptions are that elastic part of strain is negligible, the yield stress is constant, the Lévy-von Mises relations apply, and the material is isotropic. Method can be equally well applied if yield stress depends on rate of strain, but only with difficulty if it

depends on the total strain. As an illustration, the method is applied to extrusion of a cylindrical billet of lead.

R. Hill, England

2657. Moody, E. S., and Denehy, D. R., Recent strain gauge developments at A.R.L., *Aero. Res. Lab., Melbourne, Austral.* SM 211, 21 pp., Aug. 1954.

Two instruments for the measurement of direct load and torque, respectively, are described. Both instruments have unbonded strain gages as the sensitive elements. The application of recently developed "potting" techniques to strain-gage wiring is also described. Form authors' summary

2658. Frocht, M. M., Pih, H., and Landsberg, D., The use of photometric devices in the solution of the general three-dimensional photoelastic problem, *Proc. Soc. exp. Stress Anal.* **12,** 1, 181–190, 1954.

Paper describes apparatus and techniques in the application of photometry to photoelasticity. Experiments demonstrate that the precision and reproducibility of photometric measurements are excellent, isoclinics being determined with a maximum error of 0.3 degrees and retardations to within 0.002 fringes. The importance of photometry in improving the accuracy of the shear-difference method is discussed, with particular reference to the enhanced possibility of a complete solution of the general three-dimensional problem using only one model.

W. Shelson, Canada

2659. Pant, B., and Mantle, J. B., A photoelastic study of multibarrel conduits, *Proc. Soc. exp. Stress Anal.* **12,** 1, 65–78, 1954.

2660. Post, D., A new photoelastic interferometer suitable for static and dynamic measurements, *Proc. Soc. exp. Stress Anal.* **12,** 1, 191–202, 1954.

Paper describes a new form of interferometer which provides interference fringes governed by the thickness of transparent models. These interference patterns may be used to determine the sum of the principal stresses in two-dimensional problems. These data together with the values obtained from the isochromatics in photoelastic analysis may be used to calculate easily the individual principal stresses. The interferometer described permits an interference pattern composed of low-order fringes and a broad range of adjustment of fringe spacings. Construction details of the instrument are given as well as experimental confirmation of its precision.

Reviewer considers this paper to be an important contribution toward the development of a simple, robust, yet effective, isopachic interferometer. W. Shelson, Canada

2661. Mantle, J. B., Photoelastic analysis of reinforced stress raisers, *Proc. Soc. exp. Stress Anal.,* **11,** 2, 161–172, 1954.

2662. Kawata, K., Photoelastic stress analysis of rotating bodies by stress-freezing method (in Japanese) *Rep. sci. Res. Inst.* **30,** 2, 93–102, Mar. 1954.

Stress freezing method is applied to obtain stress distribution in rotating plates with holes. A circular plate with circular and oval holes and an axis of rotation normally through its center is cut in turn down to quasi-rectangular, quasi-elliptical, and quasi-rhombic shapes and successive stress distributions; in particular, stress concentrations around the holes are examined. As the original circular plate is reduced in area in the order given above, stress concentration around the oval hole left on the major axis is seen decreasing considerably. Epoxy resin is used as the photoelastic material and isochromatics are shown. Experimental technique of the freezing method is discussed.

Courtesy of Kagaku-Kenkyū-Jo Hōkoku Abstracts

2663. Kawata, K., On the cementing method for two- and three-dimensional photoelastic stress analyses (in Japanese), *Rep. sci. Res. Inst.* **30,** 5, 271–278, Sept. 1954.

For two- and three-dimensional photoelastic stress analyses, it is shown that polymers which cure by polyaddition or polymerization are suitable for model making by cementing, but those by polycondensation are not. Using cemented models made of epoxy resin—one of polymers which cure by polyaddition—good results are obtained both in stress freezing and ordinary temperature experiments on stress distributions in parallelogramic plates under transverse bending and around a spherical cavity within a cylindrical body.

Courtesy of Kagaku-Kenkyū-Jo Hōkoku Abstracts

2664. Nisida, M., and Hondo, M., Photoelastic investigation on stress concentration due to circular holes. (III) (in Japanese), *Rep. sci. Res. Inst.* **30,** 2, 49–62, Mar. 1954.

Experimental data and isochromatics are given on stress concentration around a pin joint hole in a flat bar under tension. Round- and square-headed bars with the hole, the center of which is at equal distances from the head end and two sides of the bar, are treated. The size of the hole is varied from small to nearly equal to the width of the bar.

Pressure p_θ exerted normally to upper half periphery of the hole at a point where the peripheral normal makes an angle θ with the axis of the bar is assumed as $p_\theta(2P \cos \theta)/\pi r$, where P is the tension load and r the radius of the hole.

Diagrams are prepared for design, showing relation between stress-concentration factor and size of the hole.

Courtesy of Kagaku-Kenkyū-Jo Hōkoku Abstracts

2665. Singdale, F. N., Improved brittle coatings for use under widely varying temperature conditions, *Proc. Soc. exp. Stress Anal.* **11,** 2, 173–178, 1954.

2666. Durelli, A. J., and Tsao, C. H., Use of brittle coating data in stress analysis, *Proc. Soc. exp. Stress Anal.* **11,** 1, 181–196, 1953.

Authors develop a method for determining magnitudes of both principal stresses from brittle coating data. Method can be applied using any suitable law of failure for the coating; authors assume that maximum tensile stress provides criteria of coating failure.

Crack formation by direct loading, relaxation, and refrigeration are considered.

Reviewer considers that this paper should contribute greatly to a clearer understanding of brittle coating methods of stress analysis. E. K. Frankl, England

2667. Durelli, A. J., and Okubo, S., Crack density studies in "Stresscoat," *Proc. Soc. exp. Stress Anal.* **11, 2, 153–160, 1954.**

Authors have investigated the use of the crack density in Stresscoat as a measure of strain at a point, in place of the usual method using the strain sensitivity of the coating. They have found that the crack density is independent of the strain gradient and, for a given thickness and strain sensitivity of coating, depends only on the value of the strain. Experiments have so far been limited to uniaxial stress systems.

Provided that further work shows that biaxiality does not upset the authors' conclusions, reviewer believes that this technique should prove useful in nonlinear problems where the usual methods of incremental loading cannot be employed.

E. K. Frankl, England

2668. Benjamin, J. R., Precise investigation of two model columns—experimental technique, *Proc. Soc. exp. Stress Anal.* **12, 1, 23–26, 1954.**

2669. Maher, F. J., and Becker, L. A., Dynamic tests of suspension bridge section models, *Virginia Polyt. Inst. Engng. Exp. Sta. Bull.* **98, 6, 25 pp., Apr. 1955.**

2670. Vane, F. F., The TMB portable calibrator for vibration transducers, *David W. Taylor Mod. Basin Rep.* **909, 12 pp., Nov. 1954.**

The TMB portable calibrator was designed for calibrating transducers used in measuring acceleration, velocity, or displacement, and weighing up to 1 lb. The calibrator weighs 24½ lb and its control unit weighs 11 lb. It has a usable speed range of 2 to 31.7 rps (120 to 1900 rpm) and a nominal displacement of 10 mils single amplitude. Suggestions are made for redesign in order to lower the minimum usable speed of the calibrator.

From author's summary

Rods, Beams, Cables Machine Elements

(See also Revs. 2611, 2633, 2634, 2637, 2648, 2650, 2652, 2684, 2698)

2671. Conroy, Margaret F., Plastic-rigid analysis of a special class of problems involving beams subject to dynamic transverse loading, *J. appl. Mech.* **22, 1, 48–52, Mar. 1955.**

Beams made from rigid-plastic materials with linear strain hardening are considered. If the rate of change of curvature caused by the loading is of the same sign (or zero) along the entire beams, then the differential equation of motion is of the same form as for the elastic case; hence any method suitable for solving elastic beam problems can be used. The approach, which has very limited applications, is illustrated by three examples, some of them rather unconvincingly solved.

A misprint appears in Eq. (7): the bracketed part of the integrand should not be squared. G. Sved, Australia

2672. Kammerer, A., Influence of the curvature of the neutral axis upon strength of material (in French), *Bull. Soc. Franç. Méc.* **4, 13, 35–44, 1954.**

Some analysis is given to determine the small deflections of a thin elastic beam under known forces. The cross section of the beam is arbitrary, and the neutral axis of the beam is a general twisted curve. Some particular examples are treated.

H. G. Hopkins, USA

2673. Masse, R., Computation of deformation of elements of variable cross section (in French), *Génie civ.* **132, 8, 149–153, Apr. 1955.**

2674. Williams, S. B., Analysis of the cantilever beam by means of the Laplace transform, *Proc. Soc. exp. Stress Anal.* **12, 1, 135–138, 1954.**

The Laplace transform method with spatial coordinate as the independent variable to solve beam problems is illustrated by the author with two examples. It is shown that a solution for a notched cantilever beam can be more readily obtained by this method than by the classical method. H. Lin, USA

2675. Auman, R. J., Avoiding gear tooth interference, *Prod. Engng.* **25, 11, pp. 207, 209, 211, 213, Nov. 1954.**

Simple direct method of calculating maximum diametral pitch that can be used without undercutting or using nonstandard tooth forms. Also useful in evaluating the strength advantages of pressure angles larger than 14½ deg for a given application.

From author's summary

Plates, Disks, Shells, Membranes

(See also Revs. 2636, 2649, 2650, 2711)

2676. Langefors, B., A suggested method for calculating the stresses in wings with nonrectangular plates, *SAAB Aircr. Co. Linköping, TN* **23, 11 pp., 1953.**

A suggested method for the analysis of oblique plates by the aid of superposition of elementary solutions is demonstrated. A suitable set of elementary solutions should first be sought by "orthonormalized superposition" of known solutions to elastic boundary problems. From this set, solutions for a family of nonrectangular plates can be obtained. It is shown how punched cards could be used for the main part of the computations. A simple method for using the results of the analysis of oblique plates in connection with structural analysis of oblique wings is shown. From author's summary by G. Kron, USA

2677. Bodner, S. R., The post buckling behavior of a clamped circular plate (Note), *Quart. appl. Math.* **12, 4, 397–401, Jan. 1955.**

Author extends work of K. O. Friedrichs and J. J. Stoker [*Amer. J. Math.* **63, 839–888, 1941; *J. appl. Mech.* 9, 7–14, 1942**] on simply supported circular plate to the clamped plate. Perturbation, power series, and asymptotic procedures are used to obtain solutions for different ranges of the thrust loading.

B. E. Gatewood, USA

2678. Sekiya, T., Saito, A., and Yamada, S., On the bending of a circular plate with a circular hole at the center under a concentrated load, *Proc. 2nd Japan nat. Congr. appl. Mech.*, **1952; Nat. Committee for Theor. appl. Mech., May 1953, 113–116.**

The deflection function is first obtained from the differential equation for the bending of the plate in the form containing integration constants. The expressions, which equated to zero are the boundary conditions, are then expanded in Fourier series form. The constants of the deflection function are obtained by com-

parison of like powers of cos $m\theta$. Cases when the edges are clamped or simply supported are discussed

D. N. Mitra, India

2679. **Hata, K., On the circular thick plate stressed by the generally distributed normal load,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 117–120.

The problem is an extension of the Michell-Love method of solving the plate problem. Assuming the normal load function to be expanded into a Fourier-Bessel expansion, author solves for the given plate when clamped or simply supported, taking the gradient of σ_z in Z-direction to be zero. The equation $\nabla^4 \sigma_z = 0$ is reduced to the form $\nabla_1^2\vartheta + K^2\vartheta = 0$, which is solved by Meuber's method [see "Kerbspannungslehre," chaps. II and IV].

D. N. Mitra, India

2680. **Hasegawa, M., On buckling of a clamped rhombic thin plate in shear,** *J. aero. Sci.* **21,** 10, p. 720, Oct. 1954.

Note in Readers' Forum.

2681. **Yeh, K.-y., Large deflection of a circular plate with a circular hole at the center,** *Acta Sci. Sinica* **2,** 127–144, 1953.

A treatment of the problem of transverse bending of a circular ring plate with built-in outer edge and with inner edge displaced transversely, without change of slope and horizontal displacement. The basic equations are the same as those used by Way [*Trans. ASME* **56,** 627–636, 1934] and others. Paper uses two terms of a perturbation-series solution (the first term representing the result of linear theory) and it appears as if this two-term approximation has been used for the purpose of computation without consideration of its practical range of usefulness. The author's criticism of Way's power-series method appears to this reviewer as unjustified. It should further be remarked that the same problem has previously been solved by power-series methods [K. Federhofer, *Ost. Ing.-Arch.* **1,** 21–35, 1946], that the corresponding membrane solution, ascribed to a Russian author in 1951, is due to Schwerin [*Z. tech. Phys.* **10,** 651–659, 1929], and that a perturbation solution as well as an asymptotic solution of a very similar problem has previously been discussed by the reviewer [AMR **6,** Rev. 64]. E. Reissner, USA

2682. **Plainevaux, J. E., Optimum profile of corrugated plates and pile planks** (in French), *Acad. roy. Belgique, Bull. Cl. Sci.* (5) **40,** 9, 962–969, 1954.

For the optimum efficiency, a most suitable profile of a corrugated plate is established. A rigorous solution of the problem gives an analytic expression for the form of corrugation in the following two cases: (a) for a given weight the rigidity of the plate is required to be a maximum; (b) for a prescribed rigidity the weight of the plate has to be a minimum.

W. Ornstein, USA

2683. **Reissner, E., Small rotationally symmetric deformations of shallow helicoidal shells,** *J. appl. Mech.* **22,** 1, 31–34, Mar. 1955.

Known solutions for transverse bending and plane stress of flat circular ring plates are generalized so as to apply to shallow helicoidal shells. The pitch of the middle surface of the shell is responsible for a coupling of what would be separate problems of plane stress and transverse bending for flat plates. Explicit results are obtained for an important sample problem. A general property of helicoidal cantilever shells is stated. Criteria are obtained indicating, in terms of the parameters of the shell, (a) the range of applicability of the results obtained and (b) the range in which the shell behaves like a flat plate.

From author's summary by P. M. Naghdi, USA

2684. **Wuest, W., Application of the theory of cylindrical shells** (in German), *ZAMM* **34,** 12, 444–454, Dec. 1954.

Biezeno and Grammel [AMR **7,** Rev. 694] have indicated one possible formulation of the equilibrium equations for a thin cylindrical shell subject to arbitrary loading and boundary conditions. In the present paper these equations form the basis of a consideration of the equilibrium of curved panels subject to pure bending, the plane of the bending couples coinciding with a radial plane containing a generator of the shell. It is assumed that the normal force in the direction of the generators is constant throughout the shell. With this assumption, the fourth-order differential equation for radial displacement is formulated and solved for specified boundary conditions. The relation between applied moment and the angle through which the shell generator deforms is found to be nonlinear and a critical value for the moment is established at which the shell becomes unstable. Applications to a curved leaf spring and also a bimetallic spring for a thermostat are discussed briefly. W. A. Nash, USA

2685. **Nash, W. A., Bibliography on shells and shell-like structures,** *David W. Taylor Mod. Basin Rep.* 863, 62 pp., Nov. 1954.

2686. **Okamoto, S., Tables for the approximate calculations of stresses in cylindrical shells,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952: Nat. Committee for Theor. appl. Mech., May 1953, 135–138.

2687. **Eden, J. J., Graphical method of designing thin-wall cylinders,** *Prod. Engng.* **25,** 10, 180–188, Oct. 1954.

Components that are equivalent to hollow cylinders are usually designed by successive approximations when both strength and weight are critical. This is time-consuming and cumbersome. Thus, these nomographs were developed to quickly pinpoint combinations of dimensions that satisfy cylinders subjected both to torsion and to bending. Their accuracy is adequate for all but the most precise calculations. From author's summary

2688. **Onat, E. T., and Prager, W., Limit analysis of shells of revolution. Parts I, II,** *Proc. k. Ned. Akad. Wet.* (*B*) **57,** 5, 534–548, 1954.

Paper concerns the load-carrying capacity of shells of revolution made of a plastic-rigid material that obeys Tresca's yield condition and the associated flow rule. Only axially symmetric conditions of loading and support are considered. The yield criterion is determined in terms of the stress resultants of the shell, and the associated flow rule is given in terms of the rates of extension and curvature of the middle surface. The load-carrying capacity, i.e., the load intensity at which a plastic-rigid shell would begin to deform, can be determined by the use of this yield condition and flow rule.

From authors' summary by G. de Kazinczy, Sweden

2689. Fulop, W., The rubber membrane and the solution of Laplace's equation, *Brit. J. appl. Phys.* **6,** 1, 21–23, Jan. 1955.

Previous theory of the rubber membrane predicted Laplace's equation to hold only for small inclinations of the membrane to its horizontal undisplaced position. In practice, the equation has, however, been found to hold for quite large inclinations. In addition, it has been observed that the motion of any point in the membrane is purely vertical for vertical displacements of the "electrodes." This suggested that it is the horizontal component of the tension which remains constant and equal to the tension in the undisplaced position. On this assumption it is found that Laplace's equation holds without restriction. It is interesting to note that this assumption is equivalent to assuming that vertical displacements satisfy Hooke's law, which experiments have shown to hold for quite large inclinations. From author's summary

Buckling Problems

(See Revs. 2677, 2680, 2703, 2890, 2934)

Joints and Joining Methods

(See also Rev. 2721)

2690. Tucker, L. M., and Twiss, R. B., Load diffusion in plastic structures, *Aero. Res. Counc. Lond. curr. Pap.* no. 186, 49 pp., 40 figs., Dec. 1952, published 1955.

Attachment of asbestos fiber-reinforced plastic delta wings by means of adhesives to metal aircraft frames prevents a severe problem of effectively spreading or diffusing large concentrated loads into comparatively thin reinforced plastic skins. A thoroughgoing theoretical and experimental study has resulted in glued and vacuum-molded specially shaped steel insert attachments capable of transmitting point loads exceeding 50 tons. Strength characteristics are satisfactory over the range −80 C to 90 C, with a drop of approximately 20% in the plastic, but not in the glue bond, immediately after wetting.

Molding techniques are far less important than the correct choice of materials and design of the joints.

Although this paper had its inception in aircraft problems, its treatment and usefulness are general and are applicable to the whole large field of design of joints for concentrated loads in reinforced plastics. A. G. H. Dietz, USA

2691. Eickner, H. W., Adhesive bonding properties of various metals as affected by chemical and anodizing treatments of the surfaces, *For. Prod. Lab. Rep.*, *U. S. Dept. Agric.* no. 1842-A, 9 pp., Feb. 1955.

2692. Suddarth, S. K., A spreader for use in structural nail-gluing, *Wood Res. Lab., Purdue Univ., Circ.* 408, 19 pp., Dec. 1954.

2693. Norén, B., and Englesson, T., Durability of glued joints (in Swedish), *Sven. TräforskInst. Medd.* 57B, 98 pp., 1954.

Glued laminated wood construction has had a long history in Europe, especially in Sweden (see "Studies of the strength of glued laminated wood construction," by Alan D. Freas, *For. Prod. Lab., U. S. Dept. Agric.*). This volume is a thorough report on durability of glued joints under various conditions of exposure determined on the basis of tests by the Swedish Forest Prod. Lab.

The main purpose of the tests was to determine to what extent joints of different design and with different adhesives (animal glue, casein glue, liquid urea and modified resin, acid-curing phenolic resin, resorcinol resin) can be exposed to weathering and how the shear strength is affected in the glue line by different adhesives and moisture. Four types of joints were tested: (1) Symmetrical double lap joint of large dimensions; (2) double lap joint in the cross shape; (3) scarf joint; (4) double lap joint of smaller (standard) dimensions. Specimens were tested after 2 weeks, 3, 6, and 12 months (results after 3 years will be presented in a supplement). Theoretical corroboration with test results is added.

Report is of eminent interest to designing engineers and manufacturers of glued laminated timber structures, also for the extensive bibliography referring to 70 publications.

J. J. Polivka, USA

2694. Vogel, K. C., Sawed contraction joints for concrete airfield pavements, *Nat. Res. Counc. Highway Res. Bd. Proc. 32nd Ann. Meet.*, 129–139, 1953.

2695. Thielsch, H., Testing of stainless steel weldments, *Weld. Res. Bull.* **18,** 26 pp., Sept. 1954.

Testing procedures for stainless-steel weldments can generally be divided into those in which (1) special welds are prepared (usually on plates or pipes) to serve as qualification tests for a particular welding procedure prior to its use or fabrication, (2) special weldments (also known as "mockups") are made under controlled conditions to evaluate electrode and base-metal materials, (3) a welded section is removed from fabricated equipment (as, for example, a section out of a main weld seam in a pressure vessel or pipe), and (4) completed welds are evaluated without requiring the partial destruction of the fabricated weldment (i.e., nondestructive tests). Each particular testing procedure is determined either (*a*) because of the recommendations of accepted standard specifications and codes, or (*b*) because experience has shown that this procedure will evaluate a particular property of the material, or (*c*) because of the nature of the service environments to which the completed weldment will be exposed.

From author's summary

Structures

(See also Revs. 2669, 2673, 2685, 2690, 2694, 2722, 2918)

2696. Parcel, J. I., and Moorman, R. B. B., Analysis of statically indeterminate structures, New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1955, xiv + 571 pp. $9.50.

The first half of this book is devoted to a rather complete discussion of the basic theory of deflections and statically indeterminate structures. All of the standard procedures are described and illustrated with a large number of examples worked out in great detail. The chapter on moment distribution includes a discussion of a modified method of moment distribution in which rotation and translation are permitted to take place simultaneously. This general procedure has already been described in several publications, but this is the first time that it has appeared in a book.

The second half is devoted to the solution of problems on continuous girders and trusses, rigid frames, secondary stresses, arches, and suspension bridges. The problems in this portion of the book are again worked out in considerable detail and several

of the problems are solved by more than one method. The chapter on rigid frames includes an extension of the slope-deflection method for application to frames with curved members.

Authors have had considerable experience in the field of structural engineering, both as teachers and as consulting engineers. This broad experience is reflected in their treatment of the subject of statically indeterminate structures. The book is written in greater detail than probably would be necessary for textbook use; but, on the other hand, it is this detailed treatment that makes the book more suitable for the practicing engineer who must study the material without the assistance of formal instruction. The book could be used for both undergraduate and graduate instruction in statically indeterminate structures, and there is no question but what the book would be an asset to the library of every consulting engineer in this field. C. W. McCormick, USA

2697. van Langendonck, T., Calculation of reinforced concrete [Cálculo de concreto armado], Vol. I, 2nd ed., São Paulo, Brasil, Associacão Brasileira de Cimento Portland, 1954, xxi + 500 pp.

This is the second edition of a treatise on reinforced concrete. Only the fundamental properties of concrete and steel, and the construction of the simple members loaded under tension or compression, are dealt with in this volume. The number of bibliographic references is unusually large and shows familiarity with European as well as with North and South American publications.

Some chapters, like the one dealing with supports and hinges, are presented with great detail. Also included are some phases of prestressed concrete with clear sketches of prestressing systems. The book will be useful mainly to designers and, to a smaller extent, to research men. A. J. Durelli, USA

2698. Cowan, H. J., Balanced design of prestressed concrete beams, *J. Amer. Concr. Inst.* **26,** 8, 773–784, Apr. 1955.

Equations are derived for the design of prestressed sections to develop the full value of permissible stresses in concrete both at the top and bottom of the beam during the prestressing operation as well as under the action of superimposed loads. A simple solution is obtained if the maximum permissible stresses are the same during the prestressing operation and under load. The more complicated solution for differential permissible stresses, however, gives greater economy in materials. Two examples are worked out, which demonstrate that balanced design is primarily useful for the heavily loaded beam and the beam with restricted depth.

From author's summary

The balanced section is necessarily unsymmetrical, the bottom flange being the heavier.

In light building construction the smallest area of steel is obtained from designs which are not balanced. Nevertheless, author states that balanced design represents a useful starting point in such cases.

Tables of properties for six different basic shapes, covering 175 variations are presented. P. M. Ferguson, USA

2699. Langefors, B., Exact reduction and solution by parts of equation for elastic structures, *SAAB Aircr. Co. Linköping, TN* 24, 9 pp., 1953.

Paper shows that, in structural analysis, the principle of invariant energy may be dispensed with by establishing two postulates. The first is the existence of a "primitive" structure of isolated elements obeying Hooke's law, $F = YD$. The second postulate is the existence of a topological relation $F = CF'$ ($D' = C_tD$) between the quantities (F' and D') of the interconnected structure and those of the primitive structure. The energy principle itself follows from these two principles. Author claims that this (tensorial) method is a "more fundamental, yet more simple, method than those commonly used in structures analysis."

It is also shown that, in solving complex statically indeterminate structures—such as sweptback wings—the large number of redundant forces may actually be decreased in an exact manner by first tearing apart the entire structure into isolated subdivisions. Author gives several rules for the amount of savings to be expected in inverse calculations, as influenced by choice of the type and number of subdivisions. G. Kron, USA

2700. McLeod, N. W., Some basic problems in flexible-pavement design, *Nat. Res. Counc. Highway Res. Bd. Proc. 32nd Ann. Meet.*, 90–118, 1953.

2701. Brock, J. E., Matrix analysis of piping flexibility, ASME Spring Meet., Baltimore, Md., Apr. 1955. Pap. 55—S-5, 2 pp.

Recent changes in the Piping Flexibility section of the ASA Code for Pressure Piping prompted the author to amend his detailed previous treatment of the subject [AMR 6, Rev. 2765]. Besides the Code-inspired modifications, some of the earlier tables are extended for the convenience of the user.

J. L. Lubkin, USA

2702. Margolin, M., Trussed diaphragm in a rigid bent system, *Proc. Amer. Soc. civ. Engrs.* **81,** Separ. no. 648, 13 pp., Mar. 1955.

Paper presents a method for the determination of the reactions of a system of parallel rigid bents connected together at the roof by a continuous truss. The method pertains to a system that neglects the bracing effect of roofing, siding, purlins, and girts. This method is a close approximation which employs geometric considerations based on the premise that no change in length of the chords and verticals of the roof truss takes place.

From author's summary

2703. Merchant, W., Critical loads of tall building frames, *Struct. Engr.* **33,** 3, 84–89, Mar. 1955.

2704. Muller, L. S., Bending-moment factors based on the theory of plastic hinges, *Concr. constr. Engng.* **50,** 4, 149–154, Apr. 1955.

2705. Fuchssteiner, W., Self-supporting spiral stairs (in German), *Beton u. Stahlbetonb.* **49,** 11, 252–259, Nov. 1954.

2706. Huntington, W. C., Oliver, W. A., Jackson, M. W., and Cox, W. T., Distribution of concentrated loads by laminated timber slabs, *Univ. Ill. Engng. Exp. Sta. Bull.* 424, 69 pp., Apr. 1954.

Laboratory tests were made on 119 laminated timber slabs sub-

jected to concentrated loads such as would occur on highway bridge floors.

Effects of type, size, location and spacing; effects of span length and continuity; effects of width of the slabs and the number of laminations used; effect of the number of laminations loaded; and effects of the species and moisture content of the lumber used are described. From authors' summary

2707. Egner, K., Marten, G., and Möhler, K., Experiments in the field of wood construction (Fortschritte und Forschungen im Bauwesen) (in German), Stuttgart, Franck Publishing Co., D, 9, 138 pages, 1953.

This monograph consists of six articles reporting on investigations performed by the respective authors.

(1) Egner, K., Tests on spaced, glued, two-member columns (pp. 13–26). The influences of column length, member spacers, thickness of individual members, distance between individual members, and moduli of elasticity of wood on both the bending and buckling resistances of the assembled columns were investigated. A method is advanced to compute the effective moment of inertia of such columns on the basis of the data obtained. A comparison is made between these data and those previously obtained by others.

(2) Mohler, K., Bending and buckling tests on built-up wood columns (pp. 27–54). Spaced, nailed, bolted, connectored, and glued two-member columns with spacers between or facing individual members were investigated. Variations included size of individual members, spacing of individual members, number of nails, tightened and loose bolts, use of connectors pressed into the wood (claw plates and toothed-ring connectors) and inserted into precut grooves (hardwood dowels). Bending and buckling tests with centric and eccentric load applications were performed. The test results show considerable increases in load-carrying capacity of columns with increase in the effectiveness of the fasteners and connectors used for jointing the individual members.

(3) Marten, G., Splitting and load-carrying capacity of nail joints (pp. 55–72). Single and repetitive compression and tension tests were performed on three-member air-dry fir joints with the grain of all joint members parallel and with thirty 7-in. long nails in double shear, driven from one side and not clinched. Test variations included nail spacing, nailing pattern, nailing sequence, and lumber density. Shank failure of nails was observed by the electric conductivity or nonconductivity of the nail shank during testing. Nailing sequence in rows perpendicular to grain resulted in more than twice as effective joints as nailing sequence in rows parallel to grain, even if the nail density was double that permissible according to German specifications. All repetitive tests were limited by failures of nail shanks within the joint members.

(4) Egner, K., Effectiveness of joints assembled with large nails (pp. 73–89). Tension tests parallel and compression tests perpendicular to grain of the side pieces of three-member fir joints were performed with 7 and $8^1/_2$-in. long common nails in double shear driven into (a) green lumber and tested immediately, (b) green lumber and tested when air-dry, and (c) air-dry lumber and tested immediately. Test variations included nail spacing and annual growth increments of lumber. Joint failures resulted from lumber splitting along nail rows or from exceeding the tensile strength of the lumber of which the joint was made. This indicates that some of the nail joints were stronger than the lumber. Nails driven into tension joints of air-dry lumber of slow growth at 10*d* nail spacing parallel to grain tended to split the lumber excessively and resulted in a relatively small load-carrying capacity, while similar joints of fast-grown lumber and all other joints performed satisfactorily.

(5) Enger, K., and Marten, G., Required minimum thickness of horizontal cross-jointed lumber roof sheathing (pp. 91–108). Subjected to investigation were tongue and groove sheathing, sheathing cross-nailed with a double-ended nail or steel spline, and cross-cleated sheathing to carry the prescribed concentric load. On the basis of the torsional resistance of the sheathing lumber, the free span for 0.71, 0.79, and 1-in. thick sheathing may amount to 49, 59, and 79 in., respectively, provided the cross connections between the sheathing lumber are spaced not more than 14, $16^1/_2$, and 24 in. on center. The tests and computations were based on sheathing panels over a single span, while actually the sheathing is laid continuously over multiple spans. Thus, in reviewer's opinion, the given values may be more conservative than necessary.

(6) Egner, K., Repetitively loaded 115-ft span nailed plate girder (pp. 109–138). The 98-in. high, $116^1/_2$-ft long highway bridge girders with two crosswise web-board layers at 45° to each other were assembled with partially dry fir and spruce and 12,020 wire nails in single shear, that is, 649 lb of nails per girder. Two similar girders were built and tested under repetitive load application at a rate of 170 to 210 load cycles per hour. Use of nails in double shear might have been more effective and would have reduced the number and weight of nails required, in the reviewer's opinion, and, thus, have made the design more economical.

First failure occurred in buckling of the compression flange at midspan. Upon test continuation after repair of the girder, buckling and local compression failures occurred at the compression flanges next to the flange reinforcement. Load transmission through butt joints of the compression flanges, the wet condition of the lumber as a result of exposure of the girders to the weather for the half-year test period, and the subdivision of the compression flange into several adjoining flange planks may have been of some influence on these failures. Giving consideration to such influences, the plate girder reacted to the loading in accordance with the design expectations.

Reviewer wishes to draw attention to the fact that since completion of the described studies, the interest of German researchers was aroused in both high-strength-steel and threaded nails. Their use in the tested structures would have resulted in considerable improvements and advantages to which the attention of the U. S. engineer has been drawn during the past few years.

E. G. Stern, USA

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 2641, 2642, 2656, 2671, 2688, 2730, 2731, 2737, 2890)

2708. Feltham, P., On the representation of rheological results with special reference to creep and relaxation, *Brit. J. appl. Phys.* **6**, 1, 26–31, Jan. 1955.

Generalized creep and relaxation functions are discussed on the basis of a statistical model of a stable quasi-solid material in which a distribution of relaxation centers is assumed to exist, specified as a logarithmic normal distribution of the relaxation times associated with each center. The relations are analyzed between these general functions, Andrade's creep equation, the Nutting equation, and the power law of stress relaxation.

A. M. Freudenthal, USA

2709. Prager, W., The theory of plasticity: A survey of recent achievements, *Proc. Instn. mech. Engrs.*, 3–19, 1955.

After a brief historical introduction, recent achievements in the theory of plasticity are surveyed, with emphasis on applications in mechanical engineering. Kinematic models are presented, and the advantages of those which represent stresses by displacements are pointed out. The fundamental theorems of limit analysis are discussed. Shakedown analysis and limit de-

sign are defined. Problems involving large plastic deformations are discussed with special reference to metal forming processes. Applications of the theory of plasticity to impact testing and blast damage are reviewed. Recent changes in the theory of structural stability in the plastic range are mentioned, and impending developments of the theory of plasticity are indicated. The paper is provided with numerous examples and an excellent list of references, including the most recent publications.

From author's summary by G. de Kazinczy, Sweden

2710. Sato, Y., On the discontinuity in plastic deformation (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21,** 103, 222–226, 1955.

It is generally considered that stress-strain curve is smooth in plastic range, but author found that it is not smooth when strained very slowly.

From author's experiments with solid round bars and thin hollow cylinders under torsion and with round bars under tension, it is concluded that:

(1) Stress-strain curve in plastic range is discontinuous; it consists of several branches convex downward. (2) Yield point of mild steel is the first discontinuous point. (3) The difference between the stress-strain curve of a solid cylinder and that of a hollow one is due to the influence of stress distribution. (4) The stress-strain relation at the ultimate strength under tension is just similar to that at the yield point of mild steel.

From author's summary

2711. Kunogi, M., On plastic deformation of hollow cylinder under axial compression (in Japanese), *Rep. sci. Res. Inst.* **30,** 2, 63–92, Mar. 1954.

Plastic deformation of hollow cylinders subjected to simple axial compression is studied. Two types of deformation are analyzed by von Mises' law. One is of thick-walled cylinders which keep cylindrical shape after compression under plastic conditions, while the other is plastic buckling of thin-walled cylinders which occur after axial compressive stress is reached to yielding stress. Compression tests are made on cylinders of aluminum, copper, duralumin, and 18-8 stainless steel, and experimental results are compared with analytical solutions. A method of measuring frictional coefficient between material and compression dies by change of internal or external radius of a thick-walled cylinder after compression test is suggested. True stress-strain curve is obtained approximately by compression test on an axially short cylinder by reducing the effect of friction. *Courtesy of Kagaku-Kenkyū-Jo Hōkoku Abstracts*

2712. Fritz, W., and Kroepelin, H., Viscosity measurements in non-Newtonian fluid (in German), *Kolloid Z.* **140,** 2/3, 149–157, Feb. 1955.

Authors review existing methods for obtaining functional relation between shear stress and rate of shear for non-Newtonian fluids. Capillary, concentric cylinder, and axially falling cylinder instruments are considered; their integral equations are given, as well as methods of solution. Selected references are included.

I. M. Krieger, USA

2713. Dellyes, R., Rheology of fresh cement paste (in French), *Rev. Mater. Constr.* nos. 465/466, 468; 193–213, 231–243, July/Aug., Sept. 1954.

It is shown that a fresh cement paste can be considered as a Bingham body or what author calls a plastic fluid. After reviewing theories leading to the Buckingham-Reiner and the Reiner-Rivlin equation, the first is expressed in a novel suggestive manner. An approximate calculation for the kinetic energy correction is given. The main original contribution consists in solving the rheological equation of the Bingham body for flow in a rectangular channel by means of the conformal transformation of the half plane into a half strip, using a theorem by Schwarz. The experimental part contains observations in a coaxial rotating cylinder instrument which show that some pastes exhibit thixotropy which certain admixtures, by increasing the yield stress, will not only suppress but convert into antithixotropy.

Reviewer suggests that the antithixotropy may be due to dilatancy. Many numerical examples are given, calculations being facilitated by a number of useful graphs and tables. Author does not quote the work of L'Hermite [*Ann. Inst. tech. Bât. Trav. publics*, Sept. 1949] who coined the term antithixotropy, and he seems to be unacquainted with the work of Lobanov [*Koll. Zhur.* **12,** (5) 352–358, 1950] who has determined both yield stress and plastic viscosity of fresh cement pastes and mortars by means of a similar instrument.

M. Reiner, Israel

2714. Nissan, A. H., A molecular approach to the problem of viscoelasticity (Letter to the Editor), *Nature* **175,** 4453, p. 424, Mar. 1955.

2715. Kie, T. T., Investigations on the rheological properties of clay, Thesis, Technische Hogeschool, Delft, 153 pp., 1954.

Failure, Mechanics of Solid State

(See also Revs. 2704, 2727)

2716. Johansson, C. H., Plastic deformation and the formation of cracks by detonating charges, *IngenVetenskAkad. Tidsk. Tekn. Forsk.* **26,** 1, 16–25, 1955.

Author discusses the plastic deformation and some of the fractures which may occur when an explosive charge is detonated in intimate contact with, or a high velocity fragment strikes a solid body. Several specific examples that have not been heretofore reported are described. Each example is accompanied by a brief description of the other investigations that are most likely to lead to an understanding of what has taken place in each case.

J. S. Rinehart, USA

2717. Chechulin, B. B., On statistical theory of brittle strength (in Russian), *Zh. tekh. Fiz.* **24,** 2, 292–298, Feb. 1954.

Introduction contains author's detailed analysis of the basic propositions of the two well-known statistical theories, one by W. Weibull and the other by Kontorova and Frankell. Applications of the theory of probability are different for each of these theories; hence they result in different formulas. Author establishes that the fundamental shortcomings of these theories appear to be insufficient theoretical support of the application of the distribution function for critical defects. These defects have statistical distribution over the volume and are considered to be responsible for the fracture upon loading the material. Author presents a new solution of the statistical theory by Kontorova-Frankell. For derivation of the new formula he uses Pearson's distribution function of the third type, since author considers it to be theoretically more sound and fitting for this case. This obtained new formula provides considerable improvement as compared with previous solutions. Author shows that the Weibull equation becomes a

particular case of the new equation for determining the brittle strength when the number of defects per volume is large.
V. A. Valey, USA

2718. Peterson, R. E., Relation between stress analysis and fatigue of metals, *Proc. Soc. exp. Stress Anal.* **11,** 2, 199–206, 1954.

It has been noted that there are areas of agreement between the fatigue notch factor K_f and the stress concentration factor K_t and that these are associated with the larger "notches." If, for example, one obtains data from small fatigue specimens and applies the notch factors to the design of a large number, it should be realized that the error will be on the unsafe side and could, therefore, have serious consequences. For a quite large member, such as a steam-turbine spindle, it is better to use a theoretical factor (as determined from mathematical or experimental stress analysis) than a factor obtained from small test pieces. This is because (a) it is impractical to make large tests, (b) small tests would give misleading results in an unsafe direction, and (c) the theoretical factors for fillets and groove details are well established by photoelastic and other means.
From author's summary by J. Frisch, USA

2719. Waisman, J. L., and Phillips, A., Simplified measurement of residual stresses, *Proc. Soc. exp. Stress Anal.* **11,** 2, 29–44 1954.

A rapid and accurate technique has been developed for measuring the residual stress gradient developed in plates by various manufacturing operations. This technique involves the removal, by chemical solution, of layers from one surface of a specimen containing residual stresses and the simultaneous measurement of curvature changes accompanying the removals.

A convenient fixture for making the measurements while the specimen is immersed in the etching solution is described. Charts are presented for rapid calculations of the stress pattern.

Typical residual stress gradients obtained by the use of this technique are presented. From authors' summary

2720. Leeser, D. O., and Daane, R. A., Residual stresses in a strip in terms of strain changes during electropolishing, *Proc. Soc. exp. Stress Anal.* **12,** 1, 203–208, 1954.

Residual stress may be studied by technique of removal of material from one face of specimen; electropolishing is a suitable means of doing this. Paper presents the necessary mathematical theory for examining results rather than a discussion of experiments. Uniaxial and biaxial stresses are treated. Test pieces are described. D. C. Johnson, England

2721. Odqvist, F. K. G., New approach to the theory of residual stresses in welds, *Ingen Vetensk Akad. Tidsk. Tekn. Forsk.* **25,** 6, 259–263, 1954.

Author shows that stress distribution in a butt weld is governed by a single partial differential equation. Result depends on the author's creep theory and a simplified stress and temperature model of problem. Creep theory embodies plastic-flow relations of the total strain type. Reviewer believes assumptions on the stress in the weld to be much too simple.
J. F. W. Bishop, Scotland

2722. Salgo, M. N., Examples of timber structure failures, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 544, 19 pp., Nov. 1954.

2723. Jaffe, L. D., Buffum, D. C., and Carr, F. L., The effect of various heat treating cycles upon temper brittleness, *Trans. Amer. Soc. Metals* **45,** 725–731, 1953.

2724. Beattie, H. J., Jr., and VerSnyder, F. L., Microconstituents in high temperature alloys, *Trans. Amer. Soc. Metals* **45,** 397–423, 1953.

2725. Frederick, S H., and Eden, T. F., Corrosion aspects of the vanadium problem in gas turbines, *Proc. Instn. mech. Engrs.* **168,** 3, 125–130, 1954.

Design Factors, Meaning of Material Test

(See Rev. 2704)

Material Test Techniques

(See Revs. 2655, 2712, 2713, 2732, 2733)

Mechanical Properties of Specific Materials

(See also Revs. 2639, 2694, 2697, 2698, 2706, 2710, 2711, 2713, 2715, 2722, 2917)

2726. Mills, A. P., Hayward, H. W., and Rader, L. F., Materials of construction, 6th ed., New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1955, xii + 650 pp. $7.50.

This excellent textbook covers, from an engineering standpoint, the materials which are important in mechanical as well as structural applications. Forty per cent of book is properly devoted to metals, primarily iron and steel; it includes comprehensive discussion of metallography, equilibrium diagrams, testing, service requirements including fatigue and temperature effects. Other sections deal with building stones and mineral aggregates; cementing materials; brick and clay products, refractory, heat-insulating and acoustical materials; timber; organic plastics; laminates and adhesives; organic coatings. Sections on mineral aggregates, acoustical materials, and laminates and adhesives are new in this edition, as is the discussion of air-entrained concrete. Discussion of many of the materials has been revised or expanded to include recent developments (e.g., plastics and heat-insulating materials) or to conform with latest practice (e.g., timber). Book not only presents information on properties and working stresses, but also covers manufacture of many materials in sufficient detail for engineering purposes. Information on material properties is presented not merely in handbook form but as an interpretative discussion of behavior under test. Since the book is intended as a text, questions are provided at the end of each chapter. J. D. Goldberg, USA

2727. Lipsitt, H. A., Dieter, G. E., Horne, G. T., and Mehl, R. F., Study of effects of microstructure and anisotropy on fatigue of 24S-T4 aluminum alloy, *NACA TN* 3380, 41 pp., Mar. 1955.

Report presents the results of an investigation of the statistics of the effects of variation in microstructure (extruded and extruded plus recrystallized) on the fatigue properties of 24S-T4 aluminum-alloy notched specimens tested in both the longitudinal and transverse directions.
From authors' summary

2728. **Dorn, J. E., Some fundamental experiments on high temperature creep,** *J. Mech. Phys. Solids* **3,** 2, 85–116, Jan. 1955.

Paper describes an investigation on the creep strain-stress-time relations for aluminum and aluminum alloys for various temperatures. At high temperatures, the creep strain ϵ appears to be a function of a temperature T, compensated time t, namely, $te^{-\Delta H/RT}$, and the stress. X-ray analyses and plastic properties reveal that the same structures are developed at the same values of $te^{-\Delta H/RT}$ following creep at the same stress. Thus $\epsilon = \int (te^{-\Delta H/RT})_{d\epsilon}$, for the same stress.

Relations are also proposed between the creep rate as a function of the stress. Two creep-rate stress relationships are proposed; one for high stress values and one for low stress values.

J. Marin, USA

2729. **Baldwin, E. E., The stress-rupture strength of type 347 stainless steel under cyclic temperature,** ASME Ann. Meet., N. Y., Nov. 28–Dec. 3, 1954. Pap. 54—A-231, 22 pp.

2730. **Hughes, P. J., Inge, J. E., and Prosser, S. B., Tensile and compressive stress-strain properties of some high-strength sheet alloys at elevated temperatures,** *NACA TN* 3315, 32 pp., Nov. 1954.

Results of tensile and compressive stress-strain tests at temperatures up to 1200 F are presented for SAE 4340, Hy-Tuf, Stainless W, and Inconel X sheet materials which had ultimate tensile strengths at room temperature in the 170 to 220 ksi range. Representative tensile and compressive stress-strain curves are given for each material at the test temperatures. Secant and tangent moduli, obtained from the compressive data, are included.

From authors' summary

2731. **Saunders, M. S., and Sinnott, M. J., Some properties of a nodular iron at elevated temperatures,** *Trans. Amer. Soc. Metals* **45,** 362–373, 1953.

Short-time tensile data over the temperature range of 800 to 1200 F (425 to 650 C) are presented for a typical nodular iron in two conditions: as-cast and partially annealed. Elevated temperature impact data for various exposure times over the same temperature range are presented. Stress-rupture data at 1200 F (650 C) for the iron in both conditions are included. Comparison is made with the same properties of killed carbon steel and with carbon-molybdenum steel. From the data, it appears that the properties of the nodular iron are comparable in some respects to the properties of the steels. From authors' summary

2732. **Schaefer, W., Influence of notches on tensile strength of nonmetallic materials** (in German), *Holz als Roh- und Werkstoff* **11,** 3, 91–96, Mar. 1953.

Tensile tests were performed on plain and laminated lumber, plywood, and laminated paper, with centric or eccentric bolt holes of various diameters and notches of various sizes parallel or perpendicular to the laminations and with saw kerfs. Such cuts influence considerably the stress distribution parallel and perpendicular to the direction of load application and the load-carrying capacity of the tension members.

The information presented is of particular value if the structural tension member is fully stressed, a rare case in the field of wood construction, since strength properties other than tensile strength usually are limiting factors. E. G. Stern, USA

2733. **Todd, J. D., The determination of tensile stress/strain curves for concrete,** *Proc. Inst. civ. Engrs.* **4,** 2, part 1, 201–211, Mar. 1955.

Paper compares stress-strain curves obtained from a concrete specimen in pure tension with those obtained from a plain concrete beam subjected to a transverse load.

Previous work has indicated that, in the majority of "pure" tension tests, there was, in fact, considerable eccentricity of loading present. A new form of tension test has been devised in which eccentricity of loading can be neutralized by an external bending moment. Stress-strain curves obtained by this means for various mixes of concrete are shown.

Electrical resistance strain gages were used to measure the internal strains in plain concrete beams and a method is given for calculating both tensile and compressive stress-strain curves from these results.

From author's summary by Ch. Massonnet, Belgium

2734. **Pickett, G., Flow of moisture in hardened Portland cement during freezing,** *Nat. Res. Counc. Highway Res. Bd. Proc., 32nd Ann. Meet.*, 276–284, 1953.

A mathematical analysis, based upon idealized assumptions, is made of the flow of moisture between the components of hydrated-cement paste during freezing or thawing. The components considered are the gel substance, the capillary pores, and the air-entrained spaces.

It is shown that a change in temperature for temperatures below 0 C gives rise to differences in thermodynamic potentials between gel water; capillary water, or ice; and ice frozen in the air spaces. These potentials result in part from pressures produced by volume changes resulting from freezing and, in part, from differences in the vapor pressures of ice and water. Based on these potential differences the analyses show, for example, that during freezing, in which the temperature is being lowered continuously, flow may first be from capillary to gel, then from gel to capillary, and finally again from capillary to gel. During this same time, flow may be continuously from gel to air space.

By taking into account the change in volume resulting from freezing or thawing of ice in the capillary spaces and the changes in shrinking or swelling tendency resulting from changes in amount of gel water, various volume-time temperature relations are deduced. In particular, it is shown that water movements and volume changes for a specimen depend not only on the present temperature changes but on the past temperature history of the specimen. From author's summary

2735. **Woolsey, C. C., Jr., Selection of materials for a sodium graphite reactor system,** ASME Spring Meet., Baltimore, Md., Apr. 18–21, 1955. Pap. 55—S-16, 6 pp.

Criteria are discussed for the selection of materials for components of a sodium-cooled, graphite-moderated reactor being constructed to study this type of system as a potentially economic one for a large-scale nuclear power plant. Discussion is limited to those materials in contact with the sodium coolant up to temperatures as high as 1200 F, both in the high radiation field existing within the reactor core and in the piping and heat exchangers external to the core. Materials involved are zirconium and stainless steels. Selection criteria include the usual high-temperature considerations of strength and compatibility with other materials in the system, and also their parasitic neutron absorption. From author's summary

2736. Leeser, D. O., Evaluating basic materials for nuclear-fueled power plants, ASME Spring Meet., Baltimore, Md., Apr. 18–21, 1955. Pap. 55—S-14, 4 pp.

Mechanics of Forming and Cutting

(See also Revs. 2719, 2720, 2734)

2737. Geleji, A., Rolling and forging machines [Walzwerks- und Schmiedemaschinen] (translated from Hungarian), Berlin, VEB Verlag Technik, 1954, 718 pp.

This book represents an enlarged and revised version of the 1950 Hungarian original. It was written for a dual purpose: to serve as a textbook for metallurgical engineering students and also as a manual for practicing engineers and designers engaged in the primary metal-forming field. Although the above scheme is commendable in a sense, it is bound to involve almost insurmountable difficulties in attempting to find the right balance between fundamentals and detailed design data. The reviewer believes that, in spite of definite merits, the work suffers from the author's attempt to cover too much ground in too great detail without excessively increasing the already substantial size of the book.

The text is divided into 8 sections: (1) Fundamentals of plastic forming, 15 pp.; (2) forging hammers, 125 pp.; (3) mechanical presses, 26 pp.; (4) hydraulic presses, 53 pp.; (5) rolling mills, 293 pp.; (6) tube rolling machinery 68 pp.; (7) equipment for drawing wire, tubes, and bars, 57 pp.; (8) rolling with tension, 6 pp. There are also an up-to-date bibliography (about 200 references) and a good subject index.

There is a wealth of useful and usable information in practically all the major chapters (2–7). However, the unnecessary simplifications undertaken in (1) are objectionable. For instance, although all the processes described involve large plastic deformations, many important computations are based on the constancy of volume condition $\epsilon_1 + \epsilon_2 + \epsilon_3 = 0$ (ϵ being the conventional strain), the existence of the natural strain scale being ignored altogether.

The theoretical treatment of the individual processes in the major sections represents just one, and not necessarily the best, of several possible approaches. A critical discussion on a comparative basis would have been highly desirable in a work of this type.

Notwithstanding the above criticisms, Geleji's book is the only one (to the reviewer's knowledge) to cover in fair detail virtually all of the major areas of plastic working of metals from the viewpoint of the machine designer. As such, it will certainly represent a valuable asset for the design, research, or production engineer engaged in this field. N. H. Polakowski, USA

2738. Rapier, A. C., A theoretical investigation of the temperature distribution in the metal cutting process, *Brit. J. appl. Phys.* **5,** 11, 400–405, Nov. 1954.

By relaxation method author solves problem of temperature distribution in a material with plane heat source and motion of material through the heat source in a direction perpendicular to the source. These results are then applied to compute metal-cutting temperatures resulting from work done along the shear plane. Two assumptions are associated with this application:

(1) The component of motion along the shear plane is ignored.

(2) It is assumed that the chip velocity is perpendicular to the shear plane.

The first of these is more important than the second, leading to values of heat flow into the chip that are too high. Author argues that motion along shear plane can be ignored since isotherms in work are parallel to shear plane. In reality, isotherms in the work are inclined to the shear plane, converging on the shear plane in the vicinity of the cutting point; this convergence of isotherms in work at the cutting edge is due to the component of motion along the shear plane ignored by the author. Jaeger clearly showed that the component of motion parallel to a heat source causes the maximum temperature to shift from middle of the heat source in the case of a stationary source toward the trailing edge (tool point in case of cutting-tool application). The isotherms obtained analytically by author are parallel to the shear plane only because he has ignored the Jaeger moving heat source component along cutting edge in computing them. The problem of heat transfer between tool and chip has been handled in a straightforward manner and the results give a very useful picture of cutting-tool isotherms. M. C. Shaw, USA

2739. Finnie, I., and Shaw, M. C., The friction process in metal cutting, ASME Ann. Meet., N. Y., Nov. 28–Dec. 3, 1954. Pap. 54—A-108, 12 pp.

Everyone interested in the subject of friction should study this paper regardless of whether they are interested in metal cutting. The paper analyzes the friction process in metal cutting by comparing its behavior with the classical rules of Amontons. Authors present a plausible explanation for the well-known deviations from Amontons' rules. The information contained in this analysis should prove interesting to all those concerned with cutting fluids, lubrication, and friction problems in general, particularly in the area of extreme pressure lubrication.

L. V. Colwell, USA

2740. Taniguchi, K., and Sakuma, T., Studies on friction in cold drawing (in Japanese), *Rep. sci. Res. Inst.* **30,** 3, 161–168, May 1954.

The testing machine and the specimens used are as explained in the first and second reports. In the present report, the friction between mild steel with phosphate coating and tungsten carbide is studied. Mean temperature of the friction surface is varied from a room temperature to 50, 100, 150, and 200 C and the contact pressure from 6 to 15 kg/mm². Under various conditions, diagrams are made showing the relation between the coefficient of friction and the sliding distance.

The values of the coefficient of dry friction are:

0.47	0.60	without phosphate coating
0.02	0.15	ditto but with Bonderlube as lubricant
0.05	0.63	with phosphate coating
0.02	0.07	ditto with Bonderlube as lubricant.

The coefficient tends to increase with the sliding distance and becomes almost constant beyond a certain sliding distance.
Courtesy of Kagaku-Kenkyū-Jo Hōkoku Abstracts

2741. Colwell, L. V., and McKee, R. E., Evaluation of band-saw performance. *Trans. ASME* **76,** 6, 951–960, Aug. 1954.
See AMR **7,** Rev. 1841.

2742. Galloway, D. F., Some practical aspects of cutting tool nomenclature arising from recent research, *Proc. Instn. Mech. Engrs.* **168,** 1, 67–81, 1954.

2743. Kinoshita, N., Studies on the cutting problem of bamboo (in Japanese), *Rep. sci. Res. Inst.* **30,** 3, 180–189, May 1954.

Hydraulics; Cavitation; Transport

(See also Revs. 2631, 2761, 2762, 2782, 2783, 2798, 2801, 2803)

2744. **Robertson, J. M., Water tunnels for hydraulic investigations,** ASME Spring Meet., Baltimore, Md., Apr. 18–21, 1955. Pap. 55—S-19, 19 pp.

The water tunnel is defined as a device similar to a wind tunnel for cavitation and other hydraulic testing. A list is presented of tunnels in the United States, and the various types of tunnels are described. Cavitation, the principal phenomenon of interest in most water-tunnel researches, is discussed and its scaling factor defined. The purposes and uses for which water tunnels have been built or employed are reviewed. A bibliography on cavitation and water tunnels is included.

From author's summary

2745. **Chen Che-Pen, Establishing a laminar region in an infinite rectangular channel with steepness** i_r (in French), *C. R. Acad. Sci. Paris* **240,** 4, 401–404, Jan. 1955.

2746. **Whitham, G. B., The effects of hydraulic resistance in the dam-break problem,** *Proc. roy. Soc. Lond.* (*A*) **227,** 1170, 399–407, Jan. 1955.

Author calculates the celerity of the front of a flood wave caused by the sudden break of a dam, with consideration of the effect of resistance in the tip region of the wave. The usual shallow-water theory (without consideration of resistance) is applied up to a section (the rear end of the tip region) beyond which the horizontal velocity of water is taken to be spatially constant and resistance of the stream bed is considered. The location of, and the water depth at this section are related to the local particle velocity by means of the shallow-water theory. In addition to these relationships, author applies the equation of continuity and the momentum equation to the tip region, and is able to obtain the celerity of propagation of the wave front. The result agrees fairly well with a previous one obtained by Dressler by expansion in a series of powers of the resistance parameter.

C.-S. Yih, USA

2747. **Kito, F., On pressure rise in a penstock of hydroelectric power station equipped with a surge tank,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 283–284.

2748. **Escande, L., Overpressure caused at the distributor by a break in a penstock** (in French), *Houille blanche* **9,** no. B, 692–695, Nov. 1954.

The rupture at the middle of a horizontal pipe first produces a depression at the distributor, then alternate overpressures and depressions. The overpressure obtained is relatively small when the break is not big enough to cause cavitation at the distributor, but becomes very important for larger breaks. The variation of the maximum overpressure with the size of the rupture presents curious discontinuities. From author's summary

2749. **Iwagaki, Y., On the laws of resistance to turbulence flow in open smooth channels,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 245–250.

Following Keulegan and others, author attempts to do for smooth channels what Prandtl did for pipes. He assumes that when y, the distance from the boundary, is less than $100\nu/u_*$ the mixing length is $k'(y - \delta_L)$, and that when y is greater than $100\nu/u_*$, the mixing length is $k(y - \delta_L) + L_w$. From momentum-transfer theory this enables him to derive a velocity distribution. By assuming the flow two-dimensional he is able to carry this on into expressions for mean velocity and discharge and even into criteria for stability of flow as a function of the Froude number.

He also compares the results of his mathematics with the experimental results of Matsuo, Ishihara, the reviewer, and others. The agreement is not very good, probably because the author assumed that, to convert his two-dimensional treatment into three-dimensional, it was sufficient to replace depth by hydraulic radius.

Reviewer has checked the mathematics only through Eq. (6) and finds three misprints. At the bottom of the first column, $\bar{\epsilon}$ should be negative and in line 3 of the second column $-h/B$ should be added to the expression for β. In Eq. (5), the last term should be negative. R. W. Powell, USA

2750. **Hom-ma, M., Fluid resistance in water flow of high Froude number,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 251–254.

Author wished to find whether formulas for resistance to flow in open channels, such as Manning's, apply when the Froude number exceeds one. He experimented with a wooden flume 60 cm wide and about 20 m long, at slopes of from $^1/_{500}$ to $^1/_{20}$ and depths of flow from about 1 cm to 8 cm. For wood, bare, painted with enamel, or covered with mortar, he found Manning's n between 0.0090 and 0.0105 and practically independent of the Froude number as it varied from 1.4 to 4.0. (At the upper part of this range, roll waves would be expected, but apparently were not observed.) For $F_r < 1.4$, n tended to increase, reaching about 0.012 at $F_r = 0.6$. It was noted that the surface was particularly wavy when F_r was about 1.0. When the bed was covered with crimped wire mesh, n increased to 0.022 for $F_r < 1$ and up to more than 0.023 for $F_r > 1$. Reviewer noted one misprint, the 2 being omitted from $F_r = (2i\lambda)^{1/2}$. It may also be mentioned that Iwagaki (see preceding review) found that resistance to flow in smooth channels increased with the Froude number, which is the opposite of what is found by this author.

R. W. Powell, USA

2751. **Baines, W. D., Standard roughness for river models,** *Nat. Res. Counc. Canad. mech. Engng. Rep.* MH-48, 9 pp., Oct. 1954.

The properties of $^1/_2$-in. wide flat strips are studied and data on them reanalyzed. A systematic plot for all data has been obtained in terms of relative roughness, height, and strip spacing. The use of these data in river model work is briefly reviewed.

From author's summary

2752. **Methods of using sawdust for moving bottom scale models** (in French), *Houille blanche* **9,** 3, 385–387 (French text, 381–384), June 1954.

From a hydraulic point of view and for some movable bed models, sawdust may prove to be the most satisfactory bottom material. Practically speaking, sawdust has some advantages (ease of supply, low cost) and some disadvantages (it makes a "soup"; it is not easily preserved). This article describes the treatments which can be applied to give sawdust the qualities it lacks. From summary

2753. Nechleba, M., The problem of cavitation (in German), *Maschinenbau-Technik* **4**, 2, 81–88, Feb. 1955.

Author devotes first part of paper to a review of some well-known facts and conjectures about cavitation and cavitation damage, citing only a very limited number of references (and none of the important research papers of the past few years). His main theme then concerns a damage mechanism based on electrolytic corrosion. Electric potential is assumed to be induced by differences in temperature between the attacked and surrounding metal—the heating being produced as a result of the loading in the cavitated region. Experiments carried out on turbines and magnetostriction oscillators at firms in Blansko ("Nationalunternehmen DZ") and Prague ("Anstalt für Energetik") and at the Institute of Technology, Bratislava, are cited in support of the hypothesis. Results from the oscillator experiments show that cathodic protection reduced the rate of damage (as measured by loss of weight). For polished or otherwise hardened surfaces, cathodic protection prolonged the incubation period. Rough surfaces did not exhibit an incubation period and cathodic protection was less effective. Nor was it possible to completely inhibit corrosion by cathodic protection. (In the turbine experiments, no effect was noted when the surfaces were rough.) These effects are attributed to the direct mechanical action associated with the cavity collapse pressures; here author subscribes to the damage mechanism suggested by Poulter [*J. appl. Mech.*, 1942].

The various experiments are not reported in sufficient detail to allow critical examination. P. Eisenberg, USA

2754. Shalnev, K. K., Kinematic structure of discontinuous cavitation on a rounded profile (in Russian), *Doklady Akad. Nauk SSSR* **97**, 5, 785–788, Aug. 1954.

Paper describes an experimental investigation of flow around a blunt body in the incipient and intermediate stages of cavitation, with cavities being periodically formed and swept away. The periodicity, measured by the Strouhal number S, is compared with periodicity of vortex street flow. As the cavitation number falls, S first increases and then falls. Author compares his findings with earlier work in the United States and other countries, noticing in particular the collapse and rebound of individual cavities.

A. H. Armstrong, England

2755. Chien, N., The present status of research on sediment transport, *Proc. Amer. Soc. civ. Engrs.* **80**, Separ. no. 565, 33 pp., Dec. 1954.

The problem of sediment transport, as it is known today, is discussed briefly. Emphasis is placed on the significance and implications of the various phases of the problem. Controversial issues are discussed, and efforts are made to unify some of the highly diversified results. From author's summary

Incompressible Flow: Laminar; Viscous

(See also Revs. 2692, 2745, 2777, 2780, 2796, 2798, 2800, 2815, 2816, 2817, 2848, 2849, 2852, 2854, 2886, 2887, 2903, 2907, 2939)

2756. Breslin, J. P., Two-dimensional flow about half bodies between parallel walls, *J. appl. Mech.* **22**, 1, 35–40, Mar. 1955.

Two new families of blunt half bodies are derived from the combination of source distributions and a uniform stream. One is obtained from a source lamina placed normal to an infinitely broad free stream; the other family is obtained by using the same source distribution between parallel walls. Formulas for the half-body profiles and the velocity and pressure distributions are given. Results of a calculation for selected values of the parameters are presented in graphical form, and applications of the formulas are made to give the pressure distributions on the profile and the walls. The influence of the walls on the pressure distribution and body shape is studied. An approximate relationship (obtained by neglecting the small change in body shape for large wall distances) is derived for the half-body size which may be placed between given walls with a prescribed error in the pressure at one point of the profile.

From author's summary by J. Levy, USA

2757. Yih, C.-S., Stability of two-dimensional parallel flows for three-dimensional disturbances (Note), *Quart. appl. Math.* **12**, 4, 434–435, Jan. 1955.

The object of this note is to establish a relationship between the stability of two-dimensional parallel flows for three-dimensional disturbances and that for two-dimensional ones.

From author's summary

2758. Lowry, R., Rounded corner of a 90-deg elbow, two-dimensional flow, *J. appl. Mech.* **21**, 3, 297–298, Sept. 1954.

2759. Hannum, W. H., and Griffith, W., On the intermittency of a two-dimensional jet, *J. aero. Sci.* **22**, 3, 202–203, Mar. 1955.

The intermittency of a two-dimensional jet has been investigated with a hot-wire anemometer and the statistical probability for the location of the edge of the jet is compared with measurements using a pitot tube. From authors' summary

2760. Townsin, R. L., Experiments with a low drag hydrofoil, *Quart. Trans. Instn. nav. Lond.* **97**, 1, 65–79, Jan. 1955.

Paper describes the main body of the work carried out during the author's tenure of the first Froude Research Scholarship, as an advanced student of King's College, Durham University. Experimental tests were made in the Ship Division of the National Physical Laboratory.

A symmetrical hydrofoil was designed and made with sufficient care for it to achieve a laminar boundary layer over 60% of its surface. The drag of the hydrofoil with various boundary conditions and at zero angle of incidence was measured in a towing tank by pitot traverse, and check drag measurements were made by an alternative method. Stream-flow observations were made for all conditions of the hydrofoil. The drag of the hydrofoil was calculated at zero incidence for various Reynolds numbers and transition points. From author's summary

2761. Ramsen, J. A., and Vaughan, V. L., Jr., Hydrodynamic characteristics of an aspect-ratio-0.125 modified rectangular flat plate operating near a free water surface, *NACA TN* 3249, 32 pp., Oct. 1954.

Results of an investigation of the hydrodynamic force characteristics of an aspect-ratio-0.125 modified flat plate on a single strut operating near a free water surface are presented. Comparisons between these data and similar data from previous tests on plates having aspect ratios of 1.00 and 0.25 are presented; these comparisons give the effects of aspect ratio on the characteristics. The experimental effects of varying the depth of submersion and angle of attack are shown. The effects of cavitation at the leading edge and of the planing-bubble type of high-angle separation are

presented. Comparisons are also presented between the experimental lift for all three aspect ratios at large depths of submersion and several theoretical methods of predicting the lift.

From authors' summary

2762. Williams, J., Hydrodynamic forces on obstacles due to line sources, *Quart. J. Math. Oxford Ser.* (2) **5,** 11–27, 1954.

A generalization to line sources of a result given by the reviewer [Milne-Thomson, "Theoretical hydrodynamics," 2nd ed., Macmillan, New York, 1950, p. 418; AMR **3,** Rev. 1972] for the force and moment on an obstacle due to isolated sources and doublets in inviscid irrotational incompressible flow. Applications are made to the mutual interference of n airships in line ahead in a stream and to the action on an airship in a uniform stream disturbed by a sphere. It should be noted, however, that in both cases, although the airship is defined by a given source distribution, its form is not given beforehand but is conditioned by the interference.

L. M. Milne-Thomson, England

2763. Garabedian, P. R., An example of axially symmetric flow with a free surface, "Studies in mathematics and mechanics" (presented to R. von Mises by Friends, Colleagues, and Pupils) New York, Academic Press, Inc., 149–159, 1954.

Through the use of generating functions which satisfy the differential equation of axially symmetric flow and the prescribed boundary condition, an example is presented in closed form of a steady axially symmetric flow possessing a constant-pressure free surface. Two-dimensional approximation, by a Riabouchinsky flow past two segments perpendicular to x-axis, to the analogous axisymmetric flow past two circular disks separated by a cavity, is found to be good except for sources and sinks along the axis of symmetry.

L. Talbot, USA

2764. Müller, W., Motion of an axially symmetric body in an inviscid fluid and the unstable moment of the pressure forces (in German), *Öst. Ing.-Arch.* **8,** 2/3, 171–184, 1954.

Author derives the integral expressions for the two inertia coefficients of an axially symmetric body. Case of prolate spheroid is worked out; maximum velocities are related to inertia coefficients for this special case by a simple formula.

A. E. Bryson, Jr., USA

2765. Müller, W., The determination of the inertia coefficients of an unsymmetric body of revolution (in German), *Öst. Ing.-Arch.* **8,** 4, 263–284, 1954.

In this continuation of the paper of the preceding review, author points out that dipole strength distribution for the cross flow is the same as for axial flow for prolate spheroid; he suggests this approximation for unsymmetric bodies which are not too far from being prolate spheroids. He calculates example of body formed by point source and a line sink in axial flow.

A. E. Bryson, Jr., USA

2766. Martinek, J., and Yeh, G. C. K., On potential wake and thrust deduction, *Inter. ShipBldg. Progr.* **1,** 2, 79–82, 1954.

In a recent study for the U. S. David Taylor Model Basin, the existing wake and thrust-deduction formulas have been reviewed and a new approximate formula for deeply submerged bodies of revolution in ideal potential flow has been derived. It has been found that the effective wake can be expressed in terms of the nominal wake, its gradient in the axial direction, the velocity of advance, and the propeller strength. All these quantities can be measured by testing the model and the free-running propeller in a towing tank. The new thrust-deduction formula is based upon the theorems of classical hydrodynamics following the approach of H. Dickmann and P. Weiss. The assumptions made are within conventional limits. The results indicate that the effective wake may well be a multiple of the nominal wake as many previous tests have claimed.

From authors' summary

2767. Sellars, J. R., Laminar flow in channels with porous walls at high suction Reynolds numbers, *J. appl. Phys.* **26,** 4, 489–490, Apr. 1955.

2768. Sretenskiĭ, L. N., The motion of a vibrator under the surface of a fluid (in Russian), *Trudi Moskov. Mat. Obšč.* **3,** 3–14, 1954.

Let a source of strength $Q \cos \sigma t$ move rectilinearly with constant velocity c at a distance h beneath the undisturbed surface of a heavy fluid. Using the method of stationary phase, author investigates the asymptotic form of the free surface at a great distance from the source. The problem separates into two cases: (1) $g > 4\sigma c$; (2) $g < 4\sigma c$. The result for (1) is somewhat similar to the case treated by Kelvin when the source strength is constant. The pattern for case (2) is more complex and involves an extra wedge-shaped region containing longitudinal waves.

J. V. Wehausen, USA

2769. Lin, C. C., On periodically oscillating wakes in the Oseen approximation, "Studies in mathematics and mechanics" (presented to R. von Mises by Friends, Colleagues, and Pupils), New York, Academic Press, Inc., 170–176, 1954.

In this delightfully elegant analysis concerned with the effect of viscous forces upon vortex streets in the wake of blunt bodies, author re-examines Oseen's approximation, thereby giving this theory a new look. He introduces certain further linearizing approximations, valid for vortexes not too close to the generating body, which enable him to establish neatly coordinated explicit solutions for the steady wake velocity distribution (for shallow troughs only), for the single row of alternating vortexes (which, according to Professor von Kármán's suggestion, may be applicable to oscillating airfoils), and for the double-row von Kármán street. For the latter, he derives a new expression for the spacing ratio.

In the Oseen solution as presented in the paper there appears a parameter $\beta = \nu N/U^2$, which is the ratio of Strouhal and Reynolds number (ν viscosity, N frequency, U velocity). This quantity, independent of the dimensions of the body, is identified by the author as the basic parameter governing the structure of wakes with periodic vortexes.

J. R. Weske, USA

2770. Cocchi, G., Unsteady laminar flow in a cylindrical tube of circular cross section (in Italian), *Atti Accad. naz. Lincei R. C. Sci. Fis. Mat. Nat.* (8) **15,** 1953, 393–401, 1954.

Paper gives a full discussion of the flow, uniform along the tube but not constant in time, of a viscous incompressible fluid in a tube of uniform circular cross section. Exponentially damped solutions involving Bessel functions are obtained for the case when no pressure gradient is acting. Solutions are also obtained for various time-dependent forms of external force. The results

are compared with those obtained by assuming an always parabolic distribution of velocity across the tube; this necessarily underestimates the rate of energy dissipation.

M. J. Lighthill, England

2771. Wundt, H., Decay of small swirl superimposed laminar flow in a circular tube (in German), *ZAMP* **5**, 270–276, 1954.

Collatz and Görtler [title source, **5**, 95–110, 1954; AMR **8**, Rev. 1057] examined the decay of a small axially symmetrical swirl superimposed upon steady laminar flow at high Reynolds number in a straight circular tube. The method is here extended to flow between coaxial circular cylinders. It is found that the damping of the angular momentum increases rapidly with increasing radius of the inner cylinder. D. C. Pack, Scotland

2772. Polubarinova-Kochina, P. Ya., Some plane problems of the theory of filtration of a gas in a coal seam (in Russian), *Prikl. Mat. Mekh.* **18**, 3–14, 1954.

A coal seam is assumed bounded by the negative y-axis, the positive x-axis, and by the faces of a thin slot extending from (0, 0) to (0, h). Steady-state flow of gas across the boundary is found. The paper is primarily an illustration of conformal mapping, as applied to this problem, and some of its variants.

R. E. Gaskell, USA

2773. Barenblatt, G. I., On a class of exact solutions of the plane one-dimensional problem of unsteady filtration of a gas in a porous medium (in Russian), *Prik. Mat Mekh.* **17**, 739–742, 1953.

In plane one-dimensional nonstationary filtration of a gas in a porous medium, the density of the gas satisfies the equation $\partial\rho/\partial t = a^2\partial^2\phi(\rho)/\partial x^2$, where $\phi(\rho) = \int_0^\rho \rho dp$, p being the pressure. Author assumes a solution of the form $\rho = \rho(\xi)$, where $\xi = x - ct$ ($c = \text{const} \neq 0$), and after two quadratures he finds ξ. Finally, the significance of various terms of the solution is studied and it is linked to the author's previous work.

R. E. Gaskell, USA

2774. Castoldi, L., Motion of a real fluid for which the dynamical motion equation can be linearized (in Italian), *Atti. Accad. Ligure* **9**, 1952, 222–227, 1953.

The author calls attention to the well-known fact that the acceleration field reduces to the local time derivative if and only if the streamlines are straight and the speed is instantaneously constant along them, implying that the surfaces of constant speed contain both the streamlines and the vortex lines. He finds that Navier's equations possess a certain pseudo-plane solution of this kind. C. Truesdell, USA

Compressible Flow, Gas Dynamics

(See also Revs. 2807, 2808, 2811, 2814, 2819, 2821, 2823, 2824, 2829, 2830, 2840, 2841, 2845, 2850, 2855, 2882, 2884, 2903, 2907, 2911, 2913)

2775. Giese, J. H., and Cohn, H., Canonical equations for nonlinearized steady irrotational conical flow, *Quart. appl. Math.* **12**, 4, 351–360, Jan. 1955.

Authors treat the steady compressible flow about a conical body surrounded by a conical shock. Assumptions are made that the entropy variation in the flow behind the shock is negligible and that this flow is irrotational. The conical flow assumption is introduced into the equation for the velocity potential and, following Busemann [*Luftfahrtforschung* **19**, 137–144, 1942], a Legendre contact transformation is applied, yielding a differential equation for one velocity component with the other two velocity components as independent variables. Two general parameters (μ_1, μ_2) are introduced as new independent variables and a proper choice of functional relations is made so as to lead to a system of differential equations, in a canonical form, for the three velocity components (u_i) with the new parameters as independent variables. The particular choice of functional relations depends upon whether the original equation describing the flow is elliptic or hyperbolic.

The canonical forms are systems of three quasilinear partial differential equations with the same principal parts; $\partial^2 u_i/\partial\mu_1\partial\mu_2$ for the hyperbolic case, and $(\partial^2 u_i/\partial\mu_1^2 + \partial^2 u_i/\partial\mu_2^2)$ for the elliptic case. Classes of transformations under which the forms of the systems are invariant are found and it is shown how the conical shapes of the known obstacle and unknown shock can be mapped onto known curves. In the elliptic case, the nonlinear boundary conditions are developed and, in particular, applied to a Taylor-Maccoll flow. A numerical procedure for solving the boundary-value problem is suggested. P. Chiarulli, USA

2776. Bulakh, B. M., Theory of conical flow (in Russian), *Prikl. Mat. Mekh.* **18**, 4, 451–452, July/Aug. 1954.

Author assumes the existence of an irrotational isentropic conical flow, joined in a continuous manner to a uniform supersonic stream. Using a nonlinear approximation to the potential equation in order to shed light on the nature of the singularities at the characteristic cone, he conjectures that the juncture is without jumps only in case of axisymmetric flows.

M. V. Morkovin, USA

2777. Pai, S.-I., On the stability of parallel flows with respect to periodic disturbances, *J. Franklin Inst.* **259**, 3, 197–208, Mar. 1955.

Energy method is used to establish the stability of parallel incompressible fluid flow in two dimensions with respect to periodic disturbances, both finite and infinitesimal, of the type $Re[f(y,z,t)\exp(i\lambda x)]$, x being measured in the direction of the basic flow. Poiseuille motion in a cylindrical tube of general section is shown to be always stable for this type of disturbance. Comparison is made with some previous investigations, and certain contradictory results are explained. G. Power, England

2778. Warren, W. R., Jr., The static pressure variation in compressible free jets, *J. aero. Sci.* **22**, 3, 205–207, Mar. 1955.

Note in Readers' Forum.

2779. Shima, S., Shock wave characteristics in an expanding channel, *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952: Nat. Committee for Theor. appl. Mech., May 1953, 263–266.

Author has experimentally and theoretically studied shock waves which occur in a gradually expanding channel of supercritical flow. From author's summary

2780. Stojanović, D., Temperature field in a laminar incompressible round jet and in convergent and divergent round nozzle, *J. aero. Sci.* **22**, 3, p. 216, Mar. 1955.

Note in Readers' Forum.

2781. **Talbot, L., A Mach 3.106 two-dimensional adjustable nozzle for low-density flow,** *J. aero. Sci.* **21,** 10, 708–711, Oct. 1954.

Note in Readers' Forum.

2782. **Itaya, S., and Tomita, Y., A study of high-speed gas flow by the hydraulic analogy (1st Report)** (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21,** 101, 18–21, 1955.

In order to establish an experimental method with the flowing water channel, authors discuss various factors obstructing the analogy between the water flow with free surface and two-dimensional gas flow.

This paper shows that the velocity distributions of the undisturbed flow on a vertical section of the water channel obtained by the calculation are in good agreement with the experimental results. From authors' summary

2783. **Tomita, Y., A study of high-speed gas flow by the hydraulic analogy (2nd Report)** (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21,** 101, 22–29, 1955.

In this paper, author shows, first, that the analogy between the water flow with free surface and the two-dimensional gas flow exists only when the water depth is below $6 \sim 7$ mm. Secondly, the method of determination of Mach number is given in the case where the velocity distribution of the undisturbed flow on a vertical section of the water channel is not uniform.

Furthermore, it is shown that the inclination of the water tank does not exert any influence upon the approximate analogy.

From author's summary

2784. **Krzywoblocki, M. Z. E., Bergman's linear integral operator method in the theory of compressible fluid flow. C. Axially symmetric flow and singularities,** *Öst. Ing.-Arch.* **8,** 4, 237–263, 1954.

In this third part of his work on Bergman's linear integral operator method, author first discusses axially symmetric flow where the method of infinite approximations by a sequence of linear equations is applied. A discussion of the properties of Bergman's operator, singularities, fundamental solutions, and generalization of Blasius' formulas close this part.

From author's summary

2785. **Landau, L. D., and Lifshitz, E. M., Investigation of singularities of a flow by means of the Euler-Tricomi equation** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **96,** 725–728, 1954.

Let P be the intersection of the sonic line S in a steady plane flow and a characteristic curve C at which some first partial derivatives of velocity components are discontinuous. From a two-parameter family of solutions of the Tricomi equation, approximate equations are obtained near P for S, C, the reflected characteristic from P, and the jump in derivatives of velocity components on C. J. H. Giese, USA

2786. **Bömelburg, H., The practical use of the hydraulic analogy in quantitative form for special problems in gas dynamics** (in German), *Mitt. Max-Planck-Inst. Strömungsforschung* no. 10, 70 pp., 4 figs., 8 plates, 1954.

A thorough investigation is made of the practical application of the analogy existing between the free surface flow of a shallow liquid and the flow of a two-dimensional perfect gas having a specific heat ratio of 2.

The effects of friction, boundary-layer growth, surface tension, and wave group velocity are investigated and evaluated.

The principal experimental tests consisted of towing the model in a tank of kerosene with static liquid depths of 0.22 in. or less. Kerosene was used because its surface tension was approximately $^1/_3$ that of water, thereby forming a smaller and more even meniscus about the model. This permitted the pressure-distribution evaluation about a double-wedge profile under conditions corresponding to subsonic, transonic, and supersonic flow by a measurement of the local liquid depth from a photograph of the side of the model taken by a camera near the liquid surface.

There are also some useful comments on a very complete list of references and further studies on a lattice grid and the effect of acceleration on a wedge profile. E. V. Laitone, USA

2787. **Tamada, K., and Shibaoka, Y., On supersonic flow past a finite wedge at the Crocco Mach number,** *J. aero. Sci.* 22, 4, 261–263, 269, Apr. 1955.

For the benefit of the noncognoscenti, "Crocco Mach Number" requires a definition. In the application of hodograph techniques there is a singularity in the flow at the point where the shock and leading edge meet for every Mach number except one, and this exception is the Crocco Mach number M. In general, M depends upon the geometry of the body and the ratio of specific heats γ. Application of the transonic approximation to the flow about a wedge of semivertex angle α yields the condition $(\gamma + 1)^{2/3}\alpha^{2/3}(M - 1)^{-1} = 1.6483$. The finite wedge then has drag coefficient $C_D = 2.679(\gamma + 1)^{-1/3}\alpha^{5/3}$. This very special result appears to agree well with the experiments of Liepmann and Bryson. T. R. Goodman, USA

2788. **Ferrari, C., On the determination of certain basic types of supersonic flow fields** (translation *Atti Accad. naz. Lincei R.C. Sci. Fis. Mat. Nat.* (8) **7,** 6, 277–283, 1949), *NACA TM* 1381, 17 pp., Nov. 1954.

See AMR 4, Rev. 1237.

2789. **Truitt, R. W., Pressure distribution at Mach number one over a flat plate at angle of attack,** *J. aero. Sci.* **21,** 10, p. 713, Oct. 1954.

Note in Readers' Forum.

2790. **Thomas, L. H., Computation of one-dimensional compressible flows including shocks,** *Comm. pure appl. Math.* **7,** 1, 195–206, Feb. 1954.

Two generalizations of Adams' method for numerical integration of ordinary differential equations are described in which the increment of the independent variable can be varied from step to step. These are applied to devise an efficient method for solution of canonical hyperbolic systems of partial differential equations, in particular those of one-dimensional unsteady flow referred to characteristic variables. The crux of the method is the following: It is not justified to take differences across a shock or a characteristic at which some partial derivative of some flow of function is discontinuous. To overcome this difficulty, small intervals and first backward differences of derivatives are used to start a computation from a line of discontinuity or any initial curve. Thereafter, with increasing distance from the line of discontinuity, the

interval size and order of backward differences can be increased gradually to convenient values selected in accordance with a well-known criterion for minimizing the truncation error in Adams' method. J. H. Giese, USA

2791. Cole, J. D., Acceleration of slender bodies of revolution through sonic velocity, *Guggenheim aero. Lab., Calif. Inst. of Technol., OSR tech. Note* 54–55, 13 pp., 5 figs., Jan. 1954.

Paper discusses the validity of linearized theory as applied to a slender body of revolution which accelerates uniformly through sonic speed. Using linearized theory to estimate the nonlinear terms, the importance of the parameter $(bl/c^2)^{1/2}$ (where $2b$ is acceleration, $2l$ length of body, c sound speed at infinity) is shown; transonic effects can be neglected for sufficiently long and slender missiles accelerating fast enough, i.e., high values of $(bl/c^2)^{1/2}$. It is shown that, as the acceleration increases, the drag coefficient near sonic speed decreases and approaches an asymptotic value independent of the acceleration.

F. A. Goldsworthy, England

2792. Ludloff, H. F., and Friedman, M. B., Difference solution of shock diffraction problem, *J. aero. Sci.* **22, 2,** 139–140, Feb. 1955.

Authors' previous paper [title source, **22,** 1, 27–34, Jan. 1953] proposed a method of solving numerically the reflection of a strong shock by a wedge of finite angle, which they developed from difference methods promulgated by J. von Neumann. Present paper gives very briefly some typical results of the IBM 701 machine calculations on a particular case. Three isopycnic diagrams are given which show how the results build up to the final conical field. From experience gained from this calculation, authors claim to have found a very powerful approach.

F. J. Berry, England

2793. Shoulberg, R. H., Hill, J. A. F., and Rivas, M. A., Jr., An experimental determination of flat plate recovery factors for Mach numbers between 1.90 and 3.14, *J. aero. Sci.* **21,** 11, 763–771, Nov. 1954.

An experimental investigation of temperature recovery factors on a flat piate was carried out in a continuous-type wind tunnel at the Naval Supersonic Laboratory of the Massachusetts Institute of Technology. The Mach number range for the tests lay between 1.90 and 3.14, and the Reynolds number based on the plate length extended to 17×10^6. The stagnation temperature was nominally 110 F, while stagnation pressures were varied from 6 to 31 psia.

The test results can be summarized as follows: (1) The recovery factor for the laminar boundary layer on a flat plate is independent of Mach number and equal to 0.850 ± 0.007, a value about 1% higher than the square root of the Prandtl number based on the plate surface temperature, and 2% lower than the square root of the Prandtl number based on the stream temperature. (2) The recovery factor for the turbulent boundary layer on a flat plate is independent of Mach number, but decreases slightly with Reynolds number from a value of 0.882 at a Reynolds number of 5×10^6 to a value of 0.880 at a Reynolds number of 10^7. These values of the recovery factor are about 1% lower than the cube root of the Prandtl number based on wall temperature. A maximum systematic error of ± 0.003 is possible, but this error would not affect the slight decrease of recovery factor with Reynolds number. (3) The beginning of boundary-layer transition occurs on the plate at Reynolds numbers between 1.0 and 2.4×10^6. The recovery factors in the transition zone are higher than those of the laminar and turbulent régimes, but never exceed 0.90.

From authors' summary by J. R. Stalder, USA

2794. McKee, R. M., An experimental study of the interaction of a plane shock wave with a contact region, *Univ. Toronto Inst. Aerophys. TN* no. 1, 47 pp., Sept. 1954.

Study of interaction is carried out with air in shock tube using primary contact region and shock wave reflected from end of tube. Idealized theory based on earlier work [AMR **5,** Rev. 1798; **6,** Rev. 1963; **8,** Rev. 169] predicts refraction of shock at contact surface resulting in transmitted shock of increased strength, reflected shock, and new contact surface. Data from schlieren and interference pictures show that basic departure of real flow from ideal stems from theoretical concept of contact surface as plane discontinuity. In real flow this element is replaced by region of continuous irregular change, with the result that refraction of shock wave is gradual and no reflected shock is observed. At highest pressure ratio, multiple shock-expansion combinations appear in contact region. Quantitative agreement between theory and experiment regarding path and final strength of transmitted shock is reasonably good at lower pressure ratios. Author concludes that use of this interaction for systematic study of one-dimensional shock refraction is limited.

W. G. Vincenti, USA

2795. Michel, R., Marchaud, F., and Le Gallo, J., Influence of the position of maximum thickness upon transonic flow about a pointed profile (in French), *ONERA Publ.* no. 72, 25 pp., 1954.

Experimental results are presented for Mach numbers ranging from 0.70 to 1.05 of the pressure distribution and pressure drag on several related nonlifting profiles having pointed leading and trailing edges. The position of the point of maximum thickness is varied from 30 to 70% chord and thickness ratio is varied from 6 to 12%.

One of the more interesting findings is that the variation of drag with Mach number is nearly independent of the position of the point of maximum thickness in spite of striking changes in the pressure distribution. It is shown that both the pressure distribution and drag results for airfoils of different thicknesses are related in the manner predicted by the transonic similarity rules.

J. R. Spreiter, USA

2796. Matthews, C. W., A comparison of the experimental subsonic pressure distributions about several bodies of revolution with pressure distributions computed by means of the linearized theory, *NACA Rep.* 1155, 29 pp., 1953.

Supersedes article reviewed in AMR **5,** Rev. 2895.

2797. Michel, R., Marchaud, F., and Le Gallo, J., Influence of a point of inflection on the rear of a profile in transonic flow (in French), *Rech. aéro.* no. 40, 15–19, 1954.

The object of this investigation is to compare the transonic pressure distribution and drag of a symmetrical nonlifting circular profile with that of a second profile having the same forward half, but a modified rear half terminating with a cusped trailing edge.

It is found that important differences occur in the pressure distribution and in the position of the shock wave. At Mach numbers less than about 0.97, the variation of drag with Mach number

is nearly identical for both profiles. Above this Mach number, the airfoil with modified rear has somewhat greater drag.

J. R. Spreiter, USA

2798. **Vick, A. R., and Silhan, F. V., An investigation of drains discharging liquid into subsonic and transonic streams,** *NACA TN* 3359, 54 pp., Mar. 1955.

Results of an investigation on the characteristics of drains discharging liquid into an airstream at Mach numbers from 0.5 to 1.3 are presented in the form of surface stain patterns, schlieren photographs of the flow, and drag measurements for drains of circular, elliptical, and airfoil cross-sectional shapes. Variables whose influence have been investigated include Mach number, liquid reservoir pressure, drain extension, angle of sweep, and end shape. Vent pressure data are presented as differentials between the free-stream and drain static pressure for various tube configurations. From authors' summary

2799. **Yates, A. H., The supersonic bang—a summing up,** *Ingenieur* **66,** 31, L. 39–L. 41, July 1954.

Wave Motion in Fluids

(See also Revs. 2746, 2747, 2748, 2768, 2913)

2800. **Khare, R. C., A case of tidal waves on an open sheet of water of variable depth,** *Proc. nat. Acad. Sci. India, Sect. A* **21,** 81–97, 1952.

Using the linearized shallow-water theory, author treats the wave motion in a basin with vertical walls forming a circular cylinder and a corrugated bottom, $h = h_0[1 + m \sin (r\pi/2a)]$. It is assumed that the free surface may be written $f(r) \cos s\theta$ and that m is small. A solution is obtained by a method of successive approximation in which successively higher powers of m are retained. In a final section, an angular velocity is imposed upon the fluid. The approximate solutions are expressed as power series and are not very perspicuous. J. V. Wehausen, USA

2801. **Escande, L., Superposed oscillations in surge tanks produced by successive governor operations** (in French), *Houille blanche* **9,** no. B, 689–691, Nov. 1954.

Turbulence, Boundary Layer, etc.

(See also Revs. 2749, 2767, 2833, 2887, 2890, 2905, 2927)

2802. **Chandrasekhar, S., A theory of turbulence,** *Proc. roy. Soc. Lond.* (*A*) **229,** 1176, 1–19, Apr. 1955.

On the basis of two assumptions—(1) that the turbulence is approximately steady and isotropic, and (2) that the velocity distribution in space and time has a joint probability distribution with zero fourth cumulant—author derives a single dynamical equation for the covariance of the velocity fluctuations at two points in space time. A discussion of the solutions of this equation for the case of large Reynolds numbers then follows, particular emphasis being laid on the compatibility of the equation with Kolmogoroff's theory.

However, if the reviewer understands the situation correctly, the author's approach only predicts the dependence of the covariance on the time interval when the space-interval dependence is known, or vice versa, so that the choice of the paper's title is a little misleading. For one naturally expects a theory of turbulence to make an absolute prediction about the form of the covariance in terms of over-all parameters of the flow.

I. Proudman, England

2803. **Kieda, A., On the velocity distribution of turbulent flow,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 229–232.

By considering the moment acting on an eddy due to shear stresses and making a number of assumptions, author obtained the following approximate relation

$$\partial\tau/\partial x - \partial\tau/\partial y = \rho k \nabla^2 \zeta$$

where τ is the shear stress, ζ the vorticity, and k has the dimension of length. By making various assumptions for τ and k, a number of equations for velocity profile were obtained. Von Kármán's similarity expression was used in obtaining some of the equations. When suitable values for the constants in the equations were chosen, the equations fit experimental data for various portions of the velocity profile. R. G. Deissler, USA

2804. **Mager, A., Prediction of shock-induced turbulent boundary-layer separation,** *J. aero. Sci.* **22,** 3, 201–202, Mar. 1955.

The recent experimental information by Lange [AMR **7,** Rev. 3289] indicates that the pressure coefficient required to separate a wholly turbulent boundary layer through shock is essentially independent of the Reynolds number but varies inversely with the Mach number. The purpose of this note is to show that this finding is in close agreement with the semiempirical rules used to describe the incompressible turbulent boundary-layer behavior when these rules are modified by the use of the well-known Dorodnietzyn-Stewartson transformation.

From author's summary

2805. **Furuya, Y., The velocity distribution in the turbulent boundary layer in diverging flow** (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21,** 101, 6–12, 1955.

Paper presents an analysis of the two-dimensional incompressible flow in turbulent boundary layer in diverging channel, in particular for the effects of adverse pressure gradient on the shape of the velocity distribution.

Semiempirical formulas of the skin friction and the velocity distribution near the wall are expressed in terms of the Reynolds number and a single form parameter $K = (u/U)_{y=\delta}$ that fixes the shape of the velocity distribution.

By means of these equations and equation of motion, rate of change of the parameter K with x is developed.

Comparing this method with the other methods used by previous workers, a critical survey is given.

From author's summary

2806. **Grodzovskiĭ, G. L., Equalization of the nonuniformity of velocity fields in axisymmetric turbulent and laminar flow** (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **97,** 4, 613–616, Aug. 1954.

The differential equations of motion for axisymmetric turbulent and laminar flows are written with certain simplifying assumptions and solved in terms of the mean velocity by the use of Bessel functions. Results are confirmed by the experimental test of the ejector having cylindrical mixing chamber.

A. Petroff, USA

2807. Cohen, C. B., and Reshotko, E., Similar solutions for the compressible laminar boundary layer with heat transfer and pressure gradient, *NACA TN* 3325, 67 pp., Feb. 1955.

Using Stewartson's transformation and the requirement of similarity, the laminar compressible boundary-layer equations are reduced to two nonlinear ordinary differential equations as initially derived by Stewartson [AMR **3**, Rev. 2019].

After transformation into an integral system with velocity ratio as independent parameter, solutions are obtained by digital calculations for pressure gradients ranging from the separation condition to an infinitely favorable gradient and for wall temperatures up to twice free-stream stagnation temperature.

For heated surfaces with favorable pressure gradients, the local velocity in the boundary layer may exceed the free-stream velocity. A modified Reynolds analogy parameter shows considerable variation with the pressure gradient parameter β and the surface temperature, indicating the inadequacy of using the flat plate values.

Authors do not reference the work of Li and Nagamatsu, who obtained the same differential equations by a more direct procedure not involving Stewartson's transformation [Heat Transfer and Fluid Mechanics Inst., 1954, 143–157; and *J. aero. Sci.* **21**, 12, 850–851, 1954]. Li and Nagamatsu's conclusions as to velocity overshoot in the boundary layer and, on variations of Reynolds parameter, agree with the results presented by the authors of the present paper.

F. Landis, USA

2808. Cohen, C. B., and Reshotko, E., The compressible laminar boundary layer with heat transfer and arbitrary pressure gradient, *NACA TN* 3326, 43 pp., Apr. 1955.

As an extension of prior paper (see preceding review), an approximate method for the calculation of the compressible laminar boundary layer with heat transfer and arbitrary pressure gradient, based on Thwaites' correlation concept [AMR **4**, Rev. 355], is presented. The two first-order nonlinear differential equations resulting from Stewartson's transformation are expressed in terms of dimensionless heat transfer and shear parameters. Their assumed interdependence in terms of a momentum parameter resulted in a complete system of relations for calculating skin friction and heat transfer for which temperature and velocity profiles must not be known. The dimensionless parameters were evaluated from the exact solutions presented in the preceding review.

Examples are given for two supersonic surfaces and for a highly cooled, converging-diverging, axially symmetric rocket nozzle. The nozzle calculation indicates high heat-transfer rates at the initial stagnation point and the nozzle throat and a negative displacement thickness immediately upstream of the nozzle throat.

F. Landis, USA

2809. Rotta, J. C., Similar solutions of turbulent boundary layers, *J. aero. Sci.* **22**, 3, 215–216, Mar. 1955.

Note in Readers' Forum.

2810. Uematu, T., Hatta, K., and Yamamoto, S., Solution of laminar boundary layer by the variational method (2nd Report) (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21**, 101, 13–17, 1955.

The method of solving the laminar boundary-layer equations by the variational method, which has given an excellent result for the flow along a flat plate, is applied to the retarded flow. The variational problem is solved by the Ritz method. The condition for the stationary value of the functional of the velocity distribution gives a differential equation between the length along the wall and the thickness of the boundary layer, and this equation coincides with the equation of the balance of energy in the layer. Solving this equation, the stress on the wall is calculated as the stationary value of the functional.

Some numerical examples are calculated and compared with the known solutions.

From authors' summary

2811. Truckenbrodt, E., A method of quadrature for calculation of the laminar and turbulent boundary layer in case of plane and rotationally symmetrical flow (translation from *Ing.-Arch.* **22**, 4, 211–228, 1952), *NACA TM* 1379, 40 pp., May 1955.

See AMR **6**, Rev. 1341.

2812. Kuroda, Y., Note on the fourth-order moments of random velocities, *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 219–221.

2813. Clauser, F. H., The behavior of turbulent boundary layers, *Proc. 2nd Canadian Symposium on Aerodynamics, Inst. of Aerophysics, Univ. Toronto*, Feb. 1954, 167–193.

Author reviews existing knowledge of the structure of a turbulent boundary layer in zero pressure gradient. The concepts of equilibrium and response time of boundary layers are introduced. The first is given as that state of the boundary layer "wherein it shows no tendency to change its characteristics if allowed to proceed in the same environment"; under this condition, velocity profiles are in equilibrium provided the "ratio of the pressure force to the shear force is constant." Experimental data are presented to demonstrate equilibrium. The second concept, response time, is a measure of distance required by a disturbed boundary layer to return to equilibrium. Experimental investigations show that the "inner portion of the layer near the wall responds much faster than does the outer part." From a study of equilibrium profiles in adverse pressure gradients the conclusion is drawn that "in exactly the same pressure field two widely different boundary layers can exist."

M. S. Macovsky, USA

2814. Goodman, T. R., A theory of shock-wave boundary-layer interactions, *J. aero. Sci.* **21**, 10, 715–716, Oct. 1954.

Note in Readers' Forum.

2815. Collins, G. A., The delay of turbulent separation on a flap by the use of air jets, *Aero. Res. Lab., Melbourne, Australia, Aerody. Note* 129, 13 pp., Nov. 1953.

The effectiveness of air jets for turbulent boundary-layer control has been investigated on the upper surface of an airfoil with a plain flap at a Reynolds number of 0.35×10^6. The turbulent separation from the flap surface has been delayed by a single spanwise row of air jets ahead of the flap. Changes in lift and drag brought about by the improved flow have been measured together with the flow quantity through the jets.

From author's summary

2816. Landweber, L., Frictional resistance (in German), *Jahrb. Schiffbautech. Gesellsch.* **46**, 137–150, 1952.

A recalculation of the turbulent boundary layer on a flat plate

with zero pressure gradient is presented. Author claims that his calculation, which starts from the same experimental results as others did, is more exact than previous results for the following reason: Most previous authors assumed either similar velocity profiles all along the plate (which can be shown to be quite inaccurate) or took the outer and the inner law of the turbulent velocity profile across the whole boundary layer. Author's refinement consists in taking two different laws for the turbulent velocity profile (outer and inner law, respectively). The calculated results for the boundary-layer parameters, the shearing stress, and the total skin friction are all in good agreement with measurements, the latter especially with Schoenherr's well-known formula. H. Schlichting, Germany

2817. **Kataoka, M., On the boundary layer of a plate placed parallel to the flow,** *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 453–456.

2818. **Chilton, R. G., Some measurements of atmospheric turbulence obtained from flow-direction vanes mounted on an airplane,** *NACA TN* 3313, 22 pp., Nov. 1954.

The power spectrum of high-frequency turbulence in the atmosphere was calculated from measurements made in flight. The spectrum was found to display an inverse variation with the square of frequency. This variation is in agreement with the high-frequency asymptote of the spectrum form commonly associated with isotropic turbulence. Flow-direction vanes were used to measure vertical and horizontal components of gust velocity relative to the airplane and normal to the flight direction. The power spectral densities of the two components were, for practical purposes, equal. From author's summary

Aerodynamics of Flight; Wind Forces

(See also Revs. 2616, 2676, 2690, 2818, 2845, 2847, 2850, 2856, 2860, 2867, 2903)

2819. **Kasahara, E., Extension of Kutta-Joukowsky theorem to cascade in compressible flow** (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21**, 101, 29–32, 1955.

An extension of the Kutta-Joukowsky theorem to cascades composed of thin airfoils in subsonic compressible flows holds with sufficient accuracy; namely

$$L = \rho_\infty w_\infty \Gamma, \quad L \perp w_\infty$$

where L, w_∞, ρ_∞, and Γ denote lift, velocity of vector mean flow, density corresponding to w_∞, and circulation, respectively.

From author's summary

2820. **Keune, F., Calculation of the flow past moderately thick airfoils of finite span by means of singularity distributions** (in German), *Z. Flugwiss.* **2**, 10, 253–259, Oct. 1954.

In treating an airfoil of finite span, a linearization of boundary conditions at the airfoil, as well as linearization of the flow differential equation is usually carried out. Author shows how boundary conditions at airfoil can be fulfilled more accurately. Necessary correction terms require solution of an integral equation of the same kind as for the basic flow. Position of stagnation point and flow in vicinity of rounded leading edge are discussed in some detail.

Reviewer would welcome explanations about the effects of nonlinear terms in flow differential equation and of displacement of trailing vortexes due to angle of attack and angle of yaw, for their order of magnitude in comparison to the terms considered by author is not immediately clear. G. Guderley, USA

2821. **Van Dyke, M. D., Second-order subsonic airfoil-section theory and its practical application,** *NACA TN* 3390, 50 pp., Mar. 1955.

Author modifies his second-order compressibility rule for airfoils [AMR **8**, Rev. 1421] to make it valid near stagnation points. Since subsonic-flow solution depends upon the second-order incompressible flow, comparison of the new second-order theory with known incompressible solutions is made. The resulting agreement is excellent. Also, a check of the compressible solutions by more involved analyses for simple airfoil shapes indicates a superiority of the new method.

A computation scheme, with the needed special numerical tables, is given so that the reader can determine the pressures on any given airfoil shape in purely subsonic flow.

R. E. Street, USA

2822. **Shuford, C. L., Jr., A review of planing theory and experiment with a theoretical study of pure-planing lift of rectangular flat plates,** *NACA TN* 3233, 34 pp., Aug. 1954.

A summary is given of the background and present status of the pure-planing flat-plate lift theories. The fundamental assumptions and applicability to actual calculation of the planing lift force are reviewed. A proposed theory based on the consideration of linear lifting-line theory less the suction component of lift plus crossflow effects is presented. A comparison of this theory with existing planing formulas and experimental data is made. The agreement between the results calculated by the proposed theory and the experimental data is satisfactory for engineering calculations of pure-planing rectangular-flat-plate lift and center of pressure. From author's summary

2823. **Kuessner, H. G., The difference property of the kernel of the unsteady lifting surface theory,** *J. aero. Sci.* **22**, 4, 227–230, Apr. 1955.

The kernel of the integral representation of the general solution of the linearized lifting-surface theory has the difference property. This leads to two corresponding forms of solution which give the unsteady reverse-flow theorem. From the difference property a condition of compatibility is obtained for the characteristic function G of the kernel of the harmonic three-dimensional subsonic case. By this the pressure is obtained in close analogy to the two-dimensional incompressible case.

From author's summary by G. V. R. Rao, USA

2824. **Nickel, K., The maximum lift force of a wing** (in German), *ZAMM* **34**, 10/11, 374–385, Oct./Nov. 1954.

Assumptions: planform of wing is given; its spanwise lift distribution $\gamma(y)$ is stepwise continuous and can be modified arbitrarily between fixed sectional maximal $C(y)$ and minimal $c(y)$ values by means of twist, aileron deflection, profile changes, etc. It is verified that the lift distribution $\gamma_\eta(y)$, which yields maximum total lift under the side condition of a prescribed total rolling or pitchng moment M (latter only in symmetric cases), follows the sectional maxima $C(y)$ for $y < \eta$ and sectional minima $c(y)$ for $y > \eta$. The magnitude of M affects only the location of the jump, $y = \eta$, not the above minimax character of the solution. Two examples are given. Since these optimal distributions are

not realizable, author proposes to use them as indicative of upper bounds and of trends when design parameters are varied.

M. V. Morkovin, USA

2825. Keune, F., The influence of span, thickness, incidence and Mach number on flow past wings of small and large aspect ratio (in German), *Z. Flugwiss.* **2**, 11, 292–298, Nov. 1954.

Author examines accuracy of approximate wing theories based on expansions of velocity potential in powers of the semispan σ or its reciprocal. It is assumed that wing thickness and angle of incidence are small compared with σ or $1/\sigma$. For wings of small and large span, respectively, the first, nonlinear, terms in thickness and incidence correspond to slender-body theory and plane airfoil theory; velocities in the chordwise direction and lift and moment are independent of span. Influence of Mach number on wings of small span is, to a high order of accuracy, the same as that on a body of revolution with the same distribution of cross-sectional area. For wings of large span, related plane flows all vary with Mach number, changing from hyperbolic to elliptic character, when this passes through value unity.

M. Holt, England

2826. Sacks, A. H., On slender-body theory and apparent mass, *J. aero. Sci.* **21**, 10, 713–714, Oct. 1954.

Note in Readers' Forum.

2827. Eichelbrenner, E. A., Slender-body theory, *ONERA Publ.* no. 68, 75 pp., 1954.

The wing theory of Adams and Sears [AMR **6**, Rev. 3136], which carries the Munk-Jones theory of slender wings to the second order in terms of an aspect-ratio parameter, is here extended to wings whose loading at some chordwise stations is influenced by the vortex wakes of sections farther forward. Typical wings of this class are those whose trailing as well as leading edges are swept back. The report gives a complete review of the slender-wing approximations, including the extensions of it to wing-body combinations by Ward [AMR **3**, Rev. 529] and by Adams and Sears [loc. cit.], and to wings and wing-body combinations with vortex-wake influence by Legendre, Eichelbrenner, and von Baranoff [AMR **6**, Rev. 1321]. The mathematical method used is that of Fourier (Laplace) transforms for subsonic (supersonic) flows. Application is made to wings with large sweepback; the resulting formulas require numerical integration and numerical results are to be given in a subsequent paper. Numerical results are given here for certain twisted delta wings, where analytical integrations suffice. A mathematical difficulty encountered by Adams and Sears, namely, the appearance of nonintegrable singularities in the second-order terms, does not occur in the cases treated here because of the particular planforms chosen.

W. R. Sears, USA

2828. Abzug, M. J., Effects of certain steady motions on small-disturbance airplane dynamics, *J. aero. Sci.* **21**, 11, 749–752, 762, Nov. 1954.

Linearized equations of airplane motion are derived for small disturbances from flight with certain arbitrary steady motions. The conditions studied include flight with steady coordinated turning rates, steady pitching or rolling velocities, and steady longitudinal accelerations. The equations are solved to determine the effects of these maneuvers on the small-disturbance controls-fixed modes of motion of a typical fighter-type airplane. The main results indicate that the damping of the longitudinal short-period oscillation is decreased by steady rolling, but is relatively unaffected by the other conditions. The damping of the lateral oscillation (Dutch roll) is decreased by steady turning, steady positive pitching, and steady longitudinal deceleration, but is increased by steady rolling. Spiral mode divergence is experienced in turns at high bank angles. This mode is made more convergent by steady positive pitching, steady rolling, and steady longitudinal deceleration. The rolling mode, or large real lateral root, is relatively unaffected by any of the conditions studied. These results are significant with regard to the dynamic stability of both piloted and automatically controlled flight in extreme maneuvers.

From author's summary by F. Newell, USA

2829. Margolis, K., Theoretical calculations of the pressures, forces, and moments due to various lateral motions acting on thin isolated vertical tails with supersonic leading and trailing edges, *NACA TN* 3373, 43 pp., Mar. 1955.

Linearized supersonic thin airfoil theory is applied to deduce pressures (and subsequently stability derivatives) on isolated vertical tail with all edges supersonic. Motions considered are steady rolling, steady yawing, and constant lateral acceleration. A limited study of end plates has also been undertaken; author concludes their effect on side force and yawing moment is negligible except for very small reduced aspect ratio.

T. R. Goodman, USA

2830. Martin, J. C., and Gerber, N., Effect of thickness on airfoils with constant vertical acceleration at supersonic speeds, *J. aero. Sci.* **22**, 3, 179–188, Mar. 1955.

Second-order surface pressures for symmetrical airfoils having constant vertical accelerations in uniform supersonic flows are calculated by iteration, and expressions for stability derivatives of lift and moment with respect to vertical acceleration are obtained. Numerical results are presented graphically and compared with corresponding first-order (linearized) results. An estimation of the damping of slow oscillations is made by combining the moment derivatives with respect to acceleration and pitch, the latter being taken from a paper by Martin and Gerber [AMR **8**, Rev. 749]. It is concluded that thickness has a destabilizing effect for wedge airfoils and a stabilizing effect for airfoils with parabolic profiles.

G. N. Ward, England

2831. Queijo, M. J., and Riley, D. R., Calculated subsonic span and resulting stability derivatives of unswept and 45° swept-back tail surfaces in sideslip and in steady roll, *NACA TN* 3245, 110 pp., Oct. 1954.

More detailed theoretical calculations which help to build rational design procedures are always welcome. By taking advantage of machine computation, discrete horseshoe vortexes have been utilized in sufficient number to assure reasonable accuracy in the estimation of load distributions on tail assemblies. Results are presented in terms of span loads and stability derivative contributions. Parameters varied include aspect ratios of both surfaces and the vertical position and dihedral angle of the horizontal tail.

This work extends calculations presented in *NACA Rep.* 1171 to include an aspect ratio of 0.5 for unswept tails and to include tails swept back 45°. The results, as presented, are for incompressible flow and are based on the two-dimensional lift-curve slope of 2π.

A. L. Jones, USA

2832. **Dengler, M. A., Development of charts for downwash coefficients of oscillating wings of finite span and arbitrary plan form,** *J. aero. Sci.* **21,** 12, 809–824, 834, Dec. 1954.

An outline is given for the development of charts of the downwash associated with rectangular horseshoe vortexes in incompressible oscillatory flow, and two methods are indicated of using such charts in conjunction with a single or multiple lifting-line model for calculating the circulatory spanwise loadings as well as the total lift and moment of oscillating wings of finite span. Also given is a brief outline of a complete flutter analysis using the results of such a determination in a conventional modal approach.

The downwash charts discussed in this paper, once prepared, should facilitate the calculation of the forces on oscillating wings of finite span. They should also be useful for the calculation of the downwash behind oscillating wings, a knowledge of which is required in certain studies of gust loads.

F. W. Diederich, USA

2833. **Press, H., Meadows, M. T., and Hadlock, I., Estimates of probability distribution of root-mean-square gust velocity of atmospheric turbulence from operational gust-load data by random-process theory,** *NACA TN* 3362, 48 pp., Mar. 1955.

Relations are derived between the peak gust loads experienced in airplane operations and the probability distribution of root-mean-square gust velocity. These relations are applied in the analysis of operational data on peak gust accelerations to derive estimates of the probability distribution of root-mean-square gust velocity. The application of these results to gust load calculations for other airplane operations is also considered briefly.

From authors' summary

2834. **Coleman, T. L., and Walker, W. G., Analysis of accelerations, gust velocities, and airspeeds from operations of a twin-engine transport airplane on a transcontinental route from 1950 to 1952,** *NACA TN* 3371, 16 pp., Feb. 1955.

2835. **Loftin, L. K., Jr., Airfoil section characteristics at high angles of attack,** *NACA TN* 3241, 10 pp., Aug. 1954.

Information from the literature and from recent investigations is used to summarize briefly the effects of airfoil section parameters and flow variables on the aerodynamic characteristics of symmetrical airfoils at high angles of attack. The results indicate that airfoil thickness ratio, Reynolds number, Mach number, and surface roughness can all have an important effect on the maximum lift coefficient. Beyond the stall, changes in section thickness ratio appear to have little effect on the aerodynamic characteristics of airfoil sections. From author's summary

2836. **Loftin, L. K., Jr., Aerodynamic characteristics of the NACA 64-010 and 0010-1.10 40/1.051 airfoil sections at Mach numbers from 0.30 to 0.85 and Reynolds numbers from 4.0×10^6 to 8.0×10^6,** *NACA TN* 3244, 17 pp., Aug. 1954.

The investigation covered a Mach number range from 0.30 to 0.85 and the corresponding Reynolds number range extended from 4.0×10^6 to 8.0×10^6. From author's summary

2837. **Wood, A. D., and Henshaw, D. H., Wing flow tests at subsonic and transonic speeds on four thin, low aspect ratio, swept-back wings,** *Nat. aero. Establ. Canad.* LR-118, 20 pp., 34 figs., Nov. 1954.

2838. **Draper, J. W., and Kuhn, R. E., Investigation of the aerodynamic characteristics of a model wing-propeller combination and of the wing and propeller separately at angles of attack up to 90°,** *NACA TN* 3304, 72 pp., Nov. 1954.

Results are presented of a wind-tunnel investigation of the effects of slipstream for two large-diameter propellers on the aerodynamic characteristics of a wing model. The investigation covered angles of attack from $-10°$ to $90°$ and thrust coefficients representing free-stream velocities from zero to the normal range of cruising flight. An appreciable increase in the angle of attack for maximum lift with increasing power is indicated. A modification of the method of Smelt and Davies for estimating the effects of slipstreams on the lift-curve slope is presented. Performance calculations for an assumed vertical take-off airplane are also included. Forces and moments on the wing-propeller combination and on the wing and propellers separately are included. A large nose-up pitching moment on the propeller itself was found at high angles of attack.

From author's summary

2839. **Hilton, W. F., Tests of a fairing to reduce the drag of a supersonic swept-wing root,** *J. aero. Sci.* **22,** 3, 173–178, 188, Mar. 1955.

Paper is concerned with elimination of interference at juncture of swept wing and fuselage by shaping fuselage to conform with natural streamlines over infinite yawed wing. Method used to calculate required shape is described briefly. Application is then made to 65°-sweptback wing of symmetrical section at zero lift. Pressure-distribution and shadowgraph tests at free-stream Mach number 1.73 indicate that shaping achieved purpose of reducing zero-lift drag and improving flow in vicinity of wing root. Benefits also appear at off-design angles of attack up to 4° limit of tests. For other work in same field, see also papers by Watkins [AMR **1,** Rev. 1012], Küchemann [*RAE Rep.* no. Aero. 2218, Aug. 1947], and Boddy [*NACA RM* A5OE26, Aug. 1950].

W. G. Vincenti, USA

2840. **Pendley, R. E., and Robinson, H. L., An investigation of several NACA 1-series nose inlets with and without protruding central bodies at high-subsonic Mach numbers and at a Mach number of 1.2,** *NACA TN* 3436, 51 pp., May 1955.

Measurements of pressure distribution, drag, and internal-flow pressure loss are presented for three NACA 1-series nose inlets, two of which were fitted with protruded central bodies. Test Mach number and inlet-velocity ratio ranged from 0.4 to 1.2 and from 0 to 1.34, respectively. The nose-inlet pressure drag at a Mach number of 1.2 and the central-body effects on subcritical drag, the supercritical drag rise, and the inlet total-pressure loss are discussed. From authors' summary

2841. **Dickie, G. D., Jr., Theoretical and experimental pressure recovery of sweptback normal shock inlets,** *J. aero. Sci.* 22, 3, 189–193, Mar. 1955.

The additional drag introduced at positive angles of attack is a serious handicap in the performance of jet aircraft, due to the fact that higher thrust is needed to overcome this induced drag. The actual situation is that lower thrust is available due to the poor pressure recovery at positive angles of attack.

Studies of shock flow patterns of normal shock inlets for angles of attack other than zero have shown that the detached shock wave at the entrance to these inlets was not parallel to the face of the inlet, thus necessitating some turning of the flow in-

ternally. The author concludes that "significant improvements in the angle-of-attack performance of normal shock inlets might be obtained by inclining the face of the inlet such that the expelled shock wave would be parallel to the face of the inlet and all of the turning of the flow would be accomplished externally."

Theoretical relations were established to calculate the critical total pressure recovery for the proposed devices, based upon a continuity balance and a stream-thrust balance between two inlet stations. Also, a relation for the supercritical mass-flow ratio was developed and shown to be independent of the free-stream Mach number. The theoretical results were compared to experimental results determined for actual units tested in a 4.5- by 4.5-in. supersonic wind tunnel. The two sets of results compared very well when the theoretical curves were corrected for a subsonic diffuser efficiency of 83%. Data are given for normal shock inlets having face angles of 0, 10, 20, 30, and 40 degrees for Mach numbers of 1.62 and 1.99.

As an example, the data show that the theoretical critical pressure recovery (assuming a subsonic diffuser efficiency of 100%) for a shock inlet inclined 40 degrees, an angle of attack of 15 degrees, and a Mach number of 1.99 is approximately 0.79. This is to be compared to a value of 0.725 for a noninclined inlet at zero angle of attack, and to a value of 0.675 for a noninclined inlet with an angle of attack of 15 degrees. The experimental results (and the theoretical results corrected to a subsonic diffuser efficiency of 83%) for these same conditions were 0.75, 0.70, and 0.65, respectively.

Schlieren photography was used to confirm the results for a 20-degree sweptback shock inlet at Mach 1.99 over a range of values of angle of attack.

Thus, on the assumption that the criterion of pressure recovery is valid, author has presented a concise but thorough confirmation of the original postulation of a method for improving positive angle of attack performance of shock inlets. A natural consequence of the work, as pointed out in the paper, is that critical pressure recovery is severely reduced at negative angles of attack. From a tactical standpoint this is probably not a serious limitation.

J. T. Agnew, USA

2842. Eppler, R., The optimum circling flight of a glider (in German), *Z. Flugwissen.* **2**, 1, 15–16, Jan. 1954.

A simple graphical method is given for the calculation of the optimum sinking speed in circling flight and the required flying speed from the polar diagram of a glider.

From author's summary

Aeroelasticity (Flutter, Divergence, etc.)

(See Rev. 2843)

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 2725, 2819, 2838, 2841, 2881, 2898, 2900, 2909, 2912, 2915)

2843. Baker, J. E., The effects of various parameters, including Mach number, on propeller-blade flutter with emphasis on stall flutter, *NACA TN* 3357, 40 pp., Jan. 1955.

Report presents experimental study of the effect of torsional stiffness, section-thickness ratio, sweepback, length-chord ratio, section c.g. position, blade taper, Mach number, fluid density, blade angle, and blade twist.

Most significant parameters were c.g. position and Mach number. For operation of thin blades at supersonic and supercritical speeds, the following tentative criterion for freedom from flutter is given:

(*semichord at 0.8 blade length*)(*first torsional circular frequency of blade*)/(*speed of sound in operating medium*) > 0.5.

P. C. Dunne, England

2844. Stanning, A. H., Stall propagation in cascades of airfoils, *J. aero. Sci.* **21**, 10, 711–713, Oct. 1954.

Note in Readers' Forum.

2845. Kramer, J. J., and Stanitz, J. D., Prediction of losses induced by angle of attack in cascades of sharp-nosed blades for incompressible and subsonic compressible flow, *NACA TN* 3149, 45 pp., Jan. 1955.

Paper is a tentative method of predicting pressure and total pressure losses past a cascade of blades in both incompressible and subsonic flow, without introducing viscous flow theory. Formally simple results are obtained assuming (1) forces on blades are normal to the blades (assumption may be consistent with some free streamline theory, not with standard potential-flow theory and Kutta-Joukowsky condition) and (2) deviation is the same as past a straight-blades cascade according to standard potential-flow theory.

In reviewer's opinion, method requires more physical justification; theoretically, indeed, (1) is a somewhat arbitrary assumption, and (1) and (2) are not mutually consistent.

G. Moretti, Argentina

2846. Kunz, W. J., Jr., Investigation of jet engine compressor stall and other transient characteristics, *SAE Trans.* **61**, 55–66, 1953.

Paper first describes a two-variable mechanical-electrical plotting board suitable for direct recording of test results. Limitations to response are set by a maximum pen acceleration of [350 in./sec/sec] and maximum pen traverse velocity of 30 in./sec (plotting board is 30 in. square). Author claims that when operated within its specification limits, the dynamic and static inaccuracies are less than 0.1%. He hopes to present details of electrical design in later publication.

Description is given of the application of the recording instrument and a fuel control unit to determine the fuel flow-speed relationship for maximum acceleration of a gas turbine unit. Author shows that a suitable fuel flow-speed schedule may be found from the results of approximately seven acceleration tests. The fuel control unit permits this schedule to be repeated automatically. Results show that the acceleration margin depends on the immediate past history of test program. Author explains this in terms of residual heat stored in the engine. Reviewer believes that effects of aerodynamic hysteresis in the stalled compressor blade rows should also be considered.

M. D. Wood, England

2847. Kasahara, E., A mapping theory of straight cascade of arbitrary blade section (II) (in Japanese), *Trans. Japan Soc. mech. Engrs.*, **21**, 101, 32–38, 1955.

In this paper the theory developed in the previous report [AMR **8**, Rev. 1487] is considerably simplified by using approximate boundary conditions of the same degree with the mapping function. These boundary conditions are able to determine explicitly necessary parameters involved in the mapping function. Thus the solution of the first approximation can be obtained in an explicit form. The successive approximation, if necessary, can be carried out to reach results with desired accuracy. Numerical computations are made to cascades of NACA 4412 and Clark Y 6%.

From author's summary

2848. **Mizumachi, N., and Hirayama, N., On the measurements of flow at the exit of turbine blade cascades** (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21**, 101, 38–44, 1955.

The meanings of loss coefficients that have been adopted by some investigators are considered, and it is explained that they are approximate thrust-loss coefficients or energy-loss coefficients on some assumptions. The degree of each approximation, when it is applied to two-dimensional flows, is researched by the experiments.

In the case of two-dimensional measurement, a pilot tube and a yaw meter are attached parallel, and in the case of three-dimensional measurement, both parallel and normal to the span of blades. The errors caused by two-dimensional measurement being applied to three-dimensional flow are calculated.

From authors' summary

2849. **Kofskey, M. G., and Allen, H. W., Smoke study of nozzle secondary flows in a low-speed turbine,** *NACA TN* 3260, 24 pp., Nov. 1954.

Two annular cascades of turbine nozzle blades in a transparent casing were tested separately in air at low velocity (7 fps). Smoke from oil-soaked cigars was injected at various locations and low- and high-speed motion pictures were taken. The secondary flow patterns agreed qualitatively with loss distributions from previous testing of the same cascades at high air velocity. Both high and low velocity tests indicated differing secondary flow patterns in the two cascades, the blades of which had different shapes and suction surface pressure distributions. Both cascades were also tested with a downstream rotor run at two different low speeds. W. G. Cornell, USA

2850. **Meyer, H., Supersonic stream deviation at the exit of the last low-pressure stages of steam turbines** (in German), *ZVDI* **97**, 10, 294–296, Apr. 1955.

Stream deviation is treated in the usual manner by means of continuity equation. The ratio of exit angle of deviated flow to the geometric exit angle is expressed in terms of exit specific velocity $M_2^* = c_2/c^*$ and adiabatic exponent γ. Flow patterns of some classical cascade configurations used in steam-turbine design are analyzed and compared qualitatively with Stodola's experimental results.

It is surprising that author has not used the Prandtl-Busemann characteristic method for a quantitative analysis of the stream-deviation phenomenon. The proposed flow patterns are somewhat simpler but partially incorrect; the most salient feature of exit supersonic flow is omitted, namely, the fact that, in the two-dimensional flow considered here, the local Mach number of the axial exit velocity component cannot become greater than 1.

P. Schwaar, France

2851. **Smith, K. J., and Hamrick, J. T., A rapid approximate method for the design of hub shroud profiles of centrifugal impellers of given blade shape,** *NACA TN* 3399, 26 pp., Mar. 1955.

An approximate method suitable for both design and analysis of centrifugal impellers is explained along with sample computations and hints for facilitating the calculation. The virtues of the method are that it reduces the computation time to little more than a work week (solutions used 3, 5, and 9 stream tubes with 15 hours required per stream tube), and that it does not require a high level of sophistication on the part of the user. The method is based upon the assumption of isentropic, steady, compressible, and nonviscous flow. Axial symmetry is assumed, but account is taken of tangential pressure gradients. Local values of surface velocities on both the trailing and driving faces of the blades are obtained from the calculation, plots of these along a stream tube serving as a guide to design. R. A. Burton, USA

2852. **Szczeniowski, B., Theory of the jet syphon,** *NACA TN* 3385, 49 pp., May 1955.

Author considers his adaptation of the conservation equations for one-dimensional approach new for incompressible mixing since external forces (particularly, reaction of channel wall) are included. Results are in general agreement with what others [AMR **4**, Rev. 865] have obtained for compressible case.

Derivations show that appropriate shaping of the form of the walls of the mixing zone will improve jet pump efficiency, even though no mathematical optimum conditions theoretically exist. Application of theory to case of a constant-pressure thrust augmentor is presented in an appendix. One could possibly question definition of thrust in this section. I. Glassman, USA

2853. **Hirono, M., Characteristics of involute profile-shifted gear pump** (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21**, 101, 52–56, 1955.

2854. **Miyadzu, A., Hydrodynamics of the trapping flow of a gear pump** (in Japanese), *Trans. Japan Soc. mech. Engrs.* **21**, 101, 45–51, 1955.

Paper deals with the theoretical study of the pressure rise built up in the liquid trapped between the gears at the meshing point of a gear pump, taking both the local and the convective acceleration of the trapping flow into consideration, the latter of which has been ignored in the author's former paper [AMR **8**, Rev. 1136]. The main results are: (1) The convective acceleration has the effect of raising the pressure rise, while the local acceleration has the effect of reducing it; (2) both effects are comparable and neither of them may be ignored, compared with the effect of viscosity; (3) as for the effect only of local acceleration, present result shows the same tendency and order of magnitude as the former one. From author's summary

2855. **Trommsdorff, W., Ramjets with high Mach number** (in German), *Z. Flugwiss* **2**, 9, 228–241, Sept. 1954.

2856. **Optimization of power-plant and airplane performance (Symposium)**, Presented at the Flight Propulsion Session, Twenty-Second Annual Meeting, IAS, New York, Jan. 25–29, 1954, *Aero. Engng. Rev.* **13**, 6, 42–61, June 1954.

2857. **Quick, A. W., Development problems in jet engines** (in German), *Z. Flugwiss* **2**, 9, 218–225, Sept. 1954.

2858. **Pabst, O. E., Development work on a Lorin engine,** *Z. Flugwiss.* **2**, 2, 29–40, Feb. 1954.

The report deals with the development work of the aircraft manufacturing firm Focke-Wulf-Flugzengbau-GmbH on a Lorin engine for subsonic speeds during World War II. Based on gas dynamic and thermodynamic considerations, an engine model was designed which was tested in a wind tunnel. Satisfactory agreement was reached between experiment and theory. Further development work in recent years abroad has confirmed the principles then established. From author's summary

2859. Bridle, E. A., Assessment of the relative performance of the by-pass engine and the orthodox double compound jet engine, *Aero. Res. Counc. Lond. Rep. Mem.* **2862,** 12 pp., July 1948, published 1954.

The by-pass engine can be described as a form of ducted fan engine in which the fan boosts the main compressor.

Two possible forms of by-pass engine are described, and their estimated performance is compared with that of the orthodox double compound jet engine under various flight conditions, the calculations being extended to include the case of thrust-boosting by means of exhaust reheat.

It is concluded that the by-pass engine can offer an appreciable gain in respect of fuel economy over the orthodox double compound jet engine even at 650 mph in the stratosphere, at the expense, however, of increased frontal area for a given thrust.

From author's summary

2860. Schifano, S., On the possibility of using pulsejets on gliders (in Italian), *Aerotecnica* **34,** 1, 13–15, Feb. 1954.

2861. Obradovic, N. M., The approximate deviation of the flow leaving the runner of hydraulic turbines, *Bull. Acad. Serbe Sci.* **9,** 3, 11–13, 1952.

Flow and Flight Test Techniques

(See also Revs. 2618, 2629, 2660, 2740, 2744, 2794, 2796, 2849, 2876, 2911, 2913)

2862. Misener, A. D., A portable electric velometer for low velocity liquids, *Canad. J. Technol.* **32,** 6, 242–249, Nov. 1954.

An electric instrument is described which is capable of measuring the flow velocities of liquids up to four mph with an accuracy of better than 0.1 mph. The absolute accuracy improves at lower velocities. The instrument described is self-contained and portable, suitable for study of stream velocities, erosion currents, ground runoff, etc. It may be readily adapted to become a recording velometer for any liquid, either in pipes or open channels. Its operation is not affected by sediments or suspended solids carried by the liquids. From author's summary

2863. Head, V. P., Coefficients of float-type variable-area flowmeters, *Trans. ASME* **76,** 6, 851–862, Aug. 1954.

See AMR **7,** Rev. 2961.

2864. Dean, S. K., Flow-meter for granular materials, *Engineering* **179,** 4654, 430–431, Apr. 1955.

For measuring, recording, and controlling the rate of flow of granular materials, a practical flowmeter has been developed by the British Iron and Steel Research Association which gives an output that is proportional to the rate of flow of material. Satisfactory tests have been carried out in this instrument with materials ranging from dry coke breeze to sticky iron ore; rates of flow ranging from 1.0 lb to 3.9 lb/sec were recorded within an accuracy of $\pm 2^1/_2\%$. The output is recorded by an air pressure recorder and can be used to operate a continuous control system or, in conjunction with a pressure switch, an "on-off" control system. From author's summary

2865. Pope, A., Effect of cable model mounting on wind-tunnel static pressures at high speeds, *J. aero. Sci.* **21,** 10, 716–718, Oct. 1954.

Note in Readers' Forum.

2866. Mack, L. M., Summary of existing cone temperature recovery factor data obtained in continuous flow wind tunnels plus additional data, *J. aero. Sci.* **22,** 3, 212–214, Mar. 1955.

Note in Readers' Forum.

2867. Millar, D. A. J., Assessment of a proposed jet engine icing test bed for simulating high speed flight, *Nat. aero. Establ. Canad.* LR 124, 35 pp., Feb. 1955.

Calculation and model tests were made to determine the possibilities of a tunnel for icing tests of jet engines, in which the conditions of high-speed flight could be produced. A workable configuration is proposed, employing the engine jet as an ejector to help drive the tunnel. Flight speeds from 230 to 500 mph could be simulated with the single configuration. Disadvantages would be the high noise level, the cost and size, and the need for redesign for each range of size of engine. From author's summary

2868. Vogeley, A. W., and Hart, H. A., Circumferential distribution of propeller-slipstream total-pressure rise at one radial station of a twin-engine transport airplane, *NACA TN* 3432, 24 pp., Apr. 1955.

Flight tests on a twin-engine transport airplane have been made to determine the effects of fuselage-nacelle interference on the circumferential distribution of the rise in total pressure behind the propellers. The effects of this flow interference on the operation of a simple propeller-thrust indicator, which samples the total-pressure rise at two diametrically opposed points in the slipstream (to counteract the effects of variations in angles of pitch and yaw), have been investigated. From authors' summary

2869. Schmidt, R., Application of measuring time ratios in flight testing (in German), *Z. Flugwiss.* **2,** 11, 281–292, Nov. 1954.

Principle of proposed method is to convert any quantity to be measured in an on-off signal in such a way that the ratio of the on-period and the total period of the signal is a measure for the magnitude of the pertinent quantity. This signal can both be recorded on a film strip and transmitted to the ground.

A basic investigation of the possibilities of realizing a measuring system based on this idea is carried out. No experience with an actual apparatus of this kind is given.

J. Buhrman, Holland

2870. Morris, G. J., and Lina, L. J., Description and preliminary flight investigation of an instrument for detecting subnormal acceleration during take-off, *NACA TN* 3252, 19 pp., Nov. 1954.

An instrument actuated by longitudinal acceleration and impact pressure has been proposed which would give a quick and easily recognizable quantitative indication of loss in airplane acceleration during take-off. A preliminary evaluation from flight tests of a simplified prototype instrument mounted in a jet trainer has been made. The instrument was found to be satisfactory and the response of the indicator to simulated partial power loss was rapid. From authors' summary

Thermodynamics

(See also Revs. 2734, 2780, 2781, 2852, 2855, 2856, 2857, 2859, 2901, 2908, 2915)

2871. **Herivel, J. W., A general variational principle for dissipative systems—II,** *Proc. roy. Irish Acad.* (*A*) **56,** 6, 67–75, 1954.

The author modifies his former variational principle [title source **56,** 4, 1954; AMR **8,** Rev. 1055], in which the generalized velocities are held constant. He now asserts, in effect, that the variation of the general equation of energy for a finite volume is to be zero. He applies this principle so as to derive Maxwell's equations of electromagnetism and certain equations for flows of binary mixtures of fluids. C. Truesdell, USA

2872. **Pfefferle, W. C., Jr., Goff, J. A., and Miller, J. G., Compressibility of gases. I. The Burnett method. An improved method of treatment of the data. Extension of the method to gas mixtures,** *J. chem. Phys.* **23,** 3, 509–513, Mar. 1955.

The theory of the Burnett method of measuring the compressibility of gases is discussed, and an analytical method of treating the data is presented. Determinations of the compressibility factor at 30 C for helium, nitrogen, and carbon dioxide show the convenience of the analysis and the precision that may be obtained by the method. Extension of the Burnett measurement to gas mixtures is also reported for some binary combinations of the three gases.

From authors' summary by R. A. Gross, USA

2873. **Woolley, H. W., Effect of dissociation on thermodynamic properties of pure diatomic gases,** *NACA TN* 3270, 19 pp., Apr. 1955.

Author presents graphs giving directly and easily entropy and enthalpy of oxygen, hydrogen, and nitrogen in the range 0–5000 K, 10^{-8} – 100 atm. Effects of dissociation are included, and percentage of dissociation is easily found from graphs. Results are obtained by an ingenious, simple graphical method which is described. Results indicate technically important effects of dissociation begin at approximately 1200 K for H_2 and O_2 and at 2600 K for N_2. From author's summary by S. J. Kline, USA

2874. **Mauser, H., and Kortüm, G., Notes on the thermodynamics of solutions of gases and solids in liquids** (in German), *Z. Naturforsch* **102,** 1, 42–47, Jan. 1955.

2875. **Hilsenrath, J., and Touloukian, Y. S., The viscosity, thermal conductivity, and Prandtl number for air, O_2, N_2, NO, H_2, CO, CO_2, H_2O, He, and A,** *Trans. ASME* **76,** 6, 967–983, Aug. 1954.

See AMR **7,** Rev. 1948.

2876. **Kestin, J., and Pilarczyk, K., Measurement of the viscosity of five gases at elevated pressures by the oscillating-disk method,** *Trans. ASME* **76,** 6, 987–997, Aug. 1954.

See AMR **7,** Rev. 1938.

2877. **Whalley, E., and Schneider, W. G., Compressibility of gases—VIII,** *Trans. ASME* **76,** 6, 1001–1004, Aug. 1954.

See AMR **7,** Rev. 1935.

2878. **Timan, B. L., Specific heat of gases at high temperatures** (in Russian), *Zh. eksp. teor. Fiz.* **27,** 2(8), 262–264, Aug. 1954.

Dissociation of a monatomic gas molecule into a positive ion and an electron involves an additional specific heat. The c_v-T-curve is derived by means of an energy balance and by applying simple statistical mechanics to single atoms. The specific heat curve has a maximum; in monatomic hydrogen this should be found at 18,000 K. R. Eisenschitz, England

2879. **Wellman, E. J., and Sibbitt, W. L., A survey of some of the thermodynamic and physical properties of water,** *Combustion* **26,** 10, 51–56, Apr. 1955.

Specific heat, thermal conductivity, viscosity, and Prandtl number are tabulated for compressed liquid water from 32 to 690 F and from saturation to 6000 psia. The sources of data are as follows: specific heat—Keenan and Keyes, Koch, and Smith and Keyes; thermal conductivity—Schmidt and Sellschopp, and Timroth and Vargaftig; viscosity—Dorsey, Sigwart, and Timroth. Estimated accuracies are given.

This valuable critical assembly of useful data is grievously marred in this publication. The headings of the tables are scrambled so completely that no one table has its proper heading. The correct headings appear to be as follows: Table I, Viscosity; Table II, Specific heat; Table III, Prandtl modulus; Table IV, Thermal conductivity. J. H. Keenan, USA

2880. **Li, J. C. M., and Chang, P., Self-diffusion coefficient and viscosity in liquids,** *J. chem. Phys.* **23,** 3, 518–520, Mar. 1955.

The relation between self-diffusion coefficient and viscosity is examined in terms of the early hydrodynamic theory and Eyring's kinetic theory. They differ by a factor of about 6. A detailed consideration of the kinetic theory shows that this factor should have been included in Eyring's derivation of viscosity if a proper meaning is given to the relative velocity involved.

From authors' summary by F. G. Blake, Jr., USA

2881. **Ehrat, A. J., Free-piston gas-turbine prime movers—a review of basic principles,** *Mech. Engng. N. Y.* **77,** 3, 212–216, Mar. 1955.

Heat and Mass Transfer

(See also Revs. 2738, 2780, 2807, 2808, 2875, 2879, 2904, 2926, 2927, 2930, 2931)

2882. **Denison, M. R., Tip or leading-edge temperatures on pointed heat conducting bodies at high supersonic speeds,** *J. aero. Sci.* **21,** 12, 858–860, Dec. 1954.

Author discusses the temperature of the leading edge of bodies in high velocity flow. Using an analytical approach, he shows that, for wedges and cones, the leading-edge temperature is less than the adiabatic wall temperature. The results are presented graphically in dimensionless form. A. B. Cambel, USA

2883. **Mitskevich, N. V., Some problems in the theory of heat conduction in anisotropic solids** (in Russian), *Zh. eksp. teor. Fiz.* **26,** 5, 557–561, May 1954.

The investigation of the heat-conduction equation is presented in tensor form for the case of an anisotropic solid. A particularly typical solution is obtained for the infinite body. The applica-

tion of Green functions to the derived equations leads to the solutions for the anisotropic case.

From author's summary by Y. R. Mayhew, England

2884. Petukhov, B. S., Detlaf, A. A., and Kirillov, V. V., Experimental investigation of local heat transfer of a plate in a subsonic turbulent air stream (in Russian), *Zh. tekh. Fiz.* **24,** 10, 1761–1772, Oct. 1954.

A description of the method and the results of studying local heat transfer of a plate in a linear air stream of high subsonic speed in a turbulent boundary layer. Results of experiments are represented in the form of criteria dependencies which are correct both for low- and high-speed air motions.

From authors' summary by M. D. Friedman, USA

2885. Collis, D. C., and Williams, M. J., Free convection of heat from fine wires, *Aero. Res. Lab. ARL* A140, 16 pp., 7 figs., Sept. 1954.

Paper reports on experimental study of heat transfer from fine wires (diameters from 0.000295 to 0.0041 cm) into still air. Wires and supports were enclosed in a wooden box. Heating current was supplied and resistance measurements were made by standard methods of hot-wire anemometry. Authors present data as a plot of Nusselt number (Nu) against Grashof number (Gr). By evaluating Nu at arithmetic mean temperature and Gr at ambient temperature, good correlation is obtained over the range $10^{-9} < Gr < 10^{-2}$, for various diameters and temperature loadings. Authors point out importance of conduction in transferring heat in region near the wire, as indicated by form of temperature contours on an interferogram.

Reviewer believes paper to be a useful contribution to the problem of understanding the mode of heat transfer from hot wires at low values of Reynolds number and Grashof number. The problem is not yet entirely resolved. A valuable discussion is contained in a subsequent companion paper by Mahony [*ARL* A143, Jan. 1955]. A. Roshko, USA

2886. Miesse, C. C., Ballistics of an evaporating droplet, *Jet Propulsion* **24,** 4, 237–244, July-Aug. 1954.

The motion of an evaporating droplet in a gas stream is discussed. The square of the droplet diameter decreases linearly with time and is assumed to be independent of flow velocity. The air velocity is taken to be a linear function of distance. The drag law for solid spheres in laminar flow is used.

Reviewer believes that author's results may be useful for small evaporation rates, as in spray drying. For application to combustion studies, a revised drag law is probably required.

S. S. Penner, USA

2887. Lighthill, M. J., The response of laminar skin friction and heat transfer to fluctuations in the stream velocity, *Proc. roy. Soc. Lond.* (*A*) **224,** 1156, 1–23, June 1954.

Author studies the behavior of the laminar boundary layer in two-dimensional flow when the velocity of the oncoming flow oscillates in magnitude but not in direction. Two types of approximations are introduced: (1) the high-frequency approximation, where the oscillations are essentially shear waves unaffected by the basic flow; (2) the low-frequency approximation where the oscillation is regarded as the sum of a quasi-stationary part plus a part proportional to the acceleration. For high frequencies, the maxima of skin friction anticipate the maxima of the stream velocity by 45°, while for low frequencies, the phase lead is of the form $\tan^{-1}(\omega/\omega_0)$, where ω_0 is a parameter depending on the mean motion. Author shows that it is a reasonable approximation to join the two types of approximations at $\omega = \omega_0$, thus covering the whole range of frequencies.

Heat transfer from the body is considered, with special attention to that from a heated circular cylindrical wire in a fluctuating stream in the range of Reynolds number for which a laminar boundary layer exists. It is found that the maxima of heat transfer tend to lag behind those in the stream velocity.

Detailed curves are given for the frequency dependence of various quantities of interest. Suggestions are made as to the application to turbulent boundary layers. C. C. Lin, USA

2888. Poppendiek, H. F., Forced-convection heat transfer in pipes with volume-heat sources within the fluids, *Nuclear Engng., Part I, AICE Chem. Engng. Progr. Symp. Series* no. 11, **50,** 93–104, 1954.

Analytical solutions are presented of radial temperature distribution for convective heat transfer between a long smooth pipe and fluids flowing inside the pipe. Mathematical solutions are compared favorably with experimental data with a 25% sulfuric acid solution as fluid. Analytical solutions are developed for the cases of both streamline and turbulent flow in a round pipe, under steady-state condition, with an established thermal and hydrodynamic pattern. The derivation refers to the existence of uniform volume-heat source within the fluid. Assumptions involved in the derivation are: (1) Physical properties are not affected by temperature; (2) heat transfer between fluid and wall is at a uniform flux; (3) hydrodynamic structure is defined by generalized velocity profile in turbulent region where an analogy exists between heat and momentum transfer.

During experimental investigation, the 25% sulfuric-acid solution with a constant thermal conductivity of 0.3 Btu/(hr)(sq ft)(°F/ft) was pumped through the test pipe of $^{9}/_{32}$-in. ID. Heat was generated in the fluid by passing electric current. Heat input was varied between 0.004 and 0.47 kw per cc. Reynolds number ranged from 560 to 14,000 and Prandtl number from 4.6 to 10.5.

Author believes his mathematical temperature solutions are valid for liquid metals as well as for ordinary fluids. His results may be applicable for the design of circulating-fuel nuclear reactor systems.

In view of the first assumption with regard to constancy of physical properties, the design engineer should be aware of this limitation. Testing with other fluids, including liquid metals such as sodium and bismuth, would be necessary to establish the validity of mathematical solution. J. C. Chu, USA

2889. Perry, K. P., Heat transfer by convection from a hot gas jet to a plane surface, *Instn. mech. Engrs. Proc.* **168,** 30, 775–784, 1954.

See AMR **8,** Rev. 817.

2890. Hoff, N. J., The structural effects of aerodynamic heating; Bloom, M., Appendix I, Thermal conditions associated with aircraft in flight; Kempner, J., Appendix II, Simulation of aerodynamic heating in structural testing, *Proc. 3rd AGARD Gen. Assembly, AGARD* AG6/P3, 47–81, 1 plate, Sept. 1953.

This review paper covers heat generation in the boundary layer, heat transfer, thermal stresses, material properties at high temperatures, structural behavior in the presence of creep, and high temperatures in structural testing.

Appendix I contains a useful compilation of the properties of air at various temperatures and a collection of formulas for computing heat inputs and temperature distributions. Appendix II briefly summarizes various simulated aerodynamic heating methods for structural testing. G. Gerard, USA

2891. **Loeb, W. A., First principles of heat removal from nuclear reactors. The possible conflict between temperature and power removal,** *Nuclear Engng., Part I, AICE Chem. Engng. Progr. Symp. Series* no. 11, **50,** 145–148, 1954.

For the case of a fluid coolant passing a radioactive power-generating fuel element, two equations are presented. One equation represents the quantity of heat transferred from the fuel element to the fluid, and the second represents the quantity of heat picked up by the fluid (called heat transport). On the basis of a fixed maximum fuel-element temperature, author illustrates how an increase in power level results in a decrease in coolant outlet temperature. Consideration is given to means of removing this conflict. One conclusion reached is that solid coolants, having high specific heats, may prove superior to conventional liquid coolants. L. Lapidus, USA

2892. **Lubarsky, B., and Kaufman, S. J., Review of experimental investigations of liquid-metal heat transfer,** *NACA TN* 3336, 115 pp., March 1955.

Experimental data of various investigators of liquid-metal heat-transfer characteristics were re-evaluated using as consistent assumptions and methods as possible and then compared with each other and with theoretical results. The re-evaluated data for both local fully developed and average Nusselt numbers in the turbulent flow region were found still to have considerable spread, with the bulk of the data being lower than predicted by existing analysis. An equation based on empirical grounds which represents most of the fully developed heat-transfer data is $Nu = 0.625\ Pe^{0.4}$ where Nu represents the Nusselt number and Pe the Peclet number. The theoretical prediction of the heat transfer in the entrance region was found to give lower values, in most cases, than those found in the experimental work.

From authors' summary

2893. **Perrone, G., Properties and applications of thermally sensitive resistors** (in French), *Chaleur et Industrie* **354,** 36, 3–13, Jan. 1955.

2894. **Meyer, H. I., and Garder, A. O., Mechanics of two immiscible fluids in porous media,** *J. appl. Phys.* **25,** 11, 1400–1406, Nov. 1954.

This paper describes the system of two immiscible fluids of different densities flowing in porous media. The authors are particularly concerned with oil-water, gas-oil, and gas-oil-water systems. The conditions considered in this paper are characterized by the assumed existence of a free surface between the fluids whose shape is a function of the dynamics of the flowing fluids. Formulas are derived to give the flow of oil into the well for different depths of penetration of the well into the oil sand.

J. Aronofsky, USA

2895. **Dwyer, O. E., Heat exchange in a liquid-metal-fuel reactor for power,** *Nuclear Engng., Part I, AICE Chem. Engng. Progr. Symp. Series* no. 11, **50,** 75–91, 1954.

Liquid fuel reactors are potentially a very promising type, but their development has been retarded by metallurgical and other practical problems. Paper gives broad discussion which contains much useful information about reactors in which fuel is dissolved in bismuth. Two reactor types are discussed: externally cooled, where fuel is circulated through external heat exchanger, and internally cooled, where fuel remains in reactor, with heat being removed by a suitable coolant. Sample designs for each type of system are given.

Since the uranium-bismuth reactor is one of the types being developed under AEC five-year demonstration program, reviewer feels paper is pertinent and timely. R. L. Mela, USA

2896. **Shamanskiĭ, V. E., Some applications in the theory of filtration of conformal mappings of neighboring regions with fixed points on the boundary** (in Russian), *Ukrain. mat. Zh.* **5,** 401–412, 1953.

The theory concerning mapping of a region to a nearby region, three boundary points remaining fixed, is given in some detail. Applications to some filtration problems are briefly mentioned.

R. E. Gaskell, USA

2897. **Scheidegger, A. E., Statistical hydrodynamics in porous media,** *J. appl. Phys.* **25,** 994–1001, 1954.

This lengthy discussion of the physical bases of Darcy's law and allied topics adds little to one's understanding of flow through porous media. Great emphasis is put on the fact that the results are ensemble averages over a large number of different but macroscopically identical specimens of porous material; but the neglect of any autocorrelation between successive measurements of particles of fluid detracts greatly from the interest of the statistical arguments. It is pointed out that the porous medium introduces a "dispersion" (or, more properly, a diffusion) of individual particles of fluid across the mean streamlines, though of course this does not affect the equations of the mean motion.

M. J. Lighthill, England

2898. **Kettleborough, C. F., An analogue study of the temperature distribution in cooled gas-turbine blades,** *Brit. J. appl. Phys.* **6,** 5, 174–176, May 1955.

The temperature distribution configurations obtained for two patterns of cooled turbine blade are reported. The conventional two-dimensional electrolytic tank analogy technique was employed, using models 20.6 times prototype dimension.

F. C. Hooper, Canada

2899. **Simmang, C. M., Saadeh, F. T., and Short, B. E., Heat transfer in the rotating-element air preheater,** ASME Fall Meet., Milwaukee, Wis., Sept. 8–10, 1954. Paper 54—F-22, 13 pp.

Several analytical and experimental studies of the moving surface or rotating-element regenerative heat exchangers have been made. These studies have been based, in several cases, upon steady-state conditions for the heat-transfer surfaces, although it has been recognized that the elements were heated and cooled alternately. It is the purpose of this paper to present experimental results to show the effect of the plate thickness, for a plate-type matrix for the rotor, and the time of contact of the "hot" and "cold" air on the total heat-transfer rate from the hot air to the plate or from the plate to the cold air. It is also the purpose to compare the experimental results with an analytical procedure for transient flow which is based on the assumption that the plate is alternately immersed in constant-temperature

hot air and constant-temperature cold air. In this analytical procedure it is assumed that the streams at exit from the rotor are mixed thoroughly so as to give a uniform temperature of each fluid at exit. It also is assumed that the air temperature for both hot and cold streams varies linearly with length of passage through the rotor.

From authors' summary

2900. Hahnemann, H. W., Stationary rig experiments on the heat extracting power of closed thermosyphon cooling holes, *Aero. Res. Counc. Lond. curr. Pap.* 152, 24 pp., 18 figs., Nov. 1951, published 1954.

This paper makes a valuable contribution to the basic data on physical factors influencing gas-turbine blade cooling. Measurements made with mercury, water, and oil supplied data on thermosyphon heat-transfer rates over a large range of Prandtl and Grashof numbers. A good correlation was obtained and expressed as a formula. Both open and closed thermosyphons are considered. The results can be extended to sodium or lithium and are plotted in a manner convenient for the blade designer.

Correlation methods, the relationship between stress and radial pressure rise, and overcooling effects are also discussed.

F. C. Hooper, Canada

2901. Braddon, G. D., Woolard, T. L., and Horn, E. P., Sealing regenerative-type air preheaters for high-pressure differentials, ASME Spring Meet., Baltimore, Md., Apr. 18–21, 1955. Pap. 55—S-41, 7 pp.

The full potentialities of the rotary regenerative type of heat exchanger remain to be exploited. Its advantages have yet to be realized where efficient heat transfer is in demand between fluids at high-pressure differentials. This paper reports progress in a concerted program to develop seals for the regenerative heat exchanger to advance its use for higher pressure applications.

From authors' summary

2902. Schack, A., Flow conditions and heat balance of modern soaking pits (in German), *Stahl u. Eisen* **74,** 23, 1502–1509, Nov. 1954.

Modern backfired-type soaking pit in which combustion products circulate around the stocks is found to be better in uniform heating than conventional multiple burner of sidefired type. For the former, author discusses gas flow, heat transfer, thermal efficiency, and proper working conditions of the burners. Using numerical examples, it is pointed out that: (1) Heat transfer results from forced convection, gas radiation, and back radiation from furnace wall; (2) burner giving good mixing, or short flame, should be used under high gas and air pressure so that combustion products flow with high velocity; (3) higher thermal efficiency may be obtainable with low preheating temperature rather than the higher one because it lowers gas temperature at outlet; (4) heat loss occurring by opening of furnace door should not be underestimated.

M. Kunugi, Japan

Combustion

(See also Revs. 2725, 2886, 2902)

2903. Ladenburg, R. W., editor, Part I; Lewis, B., Pease, R. N., and Taylor, H. S., editors, Part II, Physical measurements in gas dynamics and combustion (High Speed Aerodynamics and Jet Propulsion. Vol. IX), Princeton, N. J., Princeton Univ. Press, 1954, xvi + 578 pp. $12.50.

This volume by twenty-two specialists provides an excellent coverage of the whole subject of physical measurements in flowing gases and in burning gases. The treatment is simultaneously lucid, fundamental, and practical, so that the book serves excellently as a text, a source book, and personal reference book and should be invaluable to students interested in gas flow and/or combustion, as well as to established workers in the field. The coverage is very complete and the chapters authoritative. One does not receive an impression of discontinuity in going from one author to the next, attesting to good editing. Each chapter begins with an introduction and ends with an extensive bibliography, so that a standard method of employing the different chapters is soon developed by the reader.

In part I, the available experimental methods for making instantaneous local measurements of the density, pressure, velocity, and temperature of a gas stream are theoretically analyzed and described in practice. The more specialized measurements of turbulence, shock fronts, and condensation are then covered, followed by the free liquid surface table and the electrolytic tank analogs.

Part II begins with the measurement of temperature, pressure, and velocity in flames, referring specifically to their nonequilibrium character. Photographic and spectroscopic techniques are thoroughly covered in three chapters. Finally, two more chapters investigate the reaction zone and combustion wave, covering the effect of the pertinent variables on burning velocity. Though some duplication occurs in these two chapters, this is not serious, as the approaches are generally different and supplement each other.

The typography is excellent—no misprint was noted in an extensive reading of the text and examination of many equations. In short, this volume will have great utility for a long time and is a must in every gas- or flame-dynamics laboratory and university library.

C. F. Bonilla, USA

2904. Nishiwaki, N., and Haghi, S., On the evaporation and the ignition-lag of fuel droplets, *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 293–294.

2905. Tucker, M., Interaction of a free flame front with a turbulence field, *NACA TN* 3407, 55 pp., Mar. 1955.

Steady-state response of plane, infinitely extended flame front to approach stream turbulence is obtained by linearized small perturbation analysis. Viscosity is neglected. Terms arising from compressibility are retained throughout derivations but are dropped in final results. Flame front is treated as discontinuity surface. Perturbations of burning velocity and of heat release rate are introduced but not retained in final expressions. Approach turbulence field is decomposed into Fourier spectrum; single-wave transfer functions for potential flow, downstream shear flow and flame front deflection are computed; and corresponding root-mean-square quantities are obtained by integration over wave-number space. Relative increase of burning velocity over laminar value is derived as second-order quantity consisting of two terms representing increase of flame area and influence of transversal velocity fluctuations. Results indicate decrease of incremental burning velocity and increase of random pressure fluctuations, with increasing flame-temperature ratio. Flame-generated velocity fluctuations are found to be of about the same intensity as incident turbulence.

Reviewer suggested approach of present work previously [AMR 7, Rev. 2306] but doubts validity of steady-state analysis based on mathematical model that has divergent transient solu-

tion [Darrieus, G., *Inter. Congr. appl. Mech.*, Paris 1946; Landau L., *Acta Physicochim. USSR* **19**, 77, 1944].

G. H. Markstein, USA

2906. **Macioce, E., Combustion instability in liquid propellant rocket motors. Low-frequency oscillatory phenomena** (in Italian), *Aerotecnica* **34**, 6, 319–325, Dec. 1954.

Following general considerations about low-frequency instability in liquid propellant rocket motors, systems with constant pressure and constant rate supply and with servostabilization of low-frequency oscillations (conforming to analyses of Tischler and Bellman, Crocco, Tsien) are examined. Finally, theoretical results and experimental investigations for a particular case (constant pressure supply) are compared.

From author's summary

2907. **Fay, J. A., The distributions of concentration and temperature in a laminar jet diffusion flame,** *J. aero. Sci.* **21**, 10, 681–689, Oct. 1954.

From the equations of motion, diffusion, and heat transfer, author shows that, in laminar two-dimensional and axially symmetric flow, temperature and mass concentration are linearly related to velocity, provided Prandtl and Schmidt numbers are unity and the specific heat is constant. It is shown that this result can be applied to a laminar jet of flame if Burke and Schumann's simplified picture of a thin flame surface with diffusion of oxidant and fuel from opposite sides is assumed. The flame front is found to be a constant velocity surface whose temperature is the adiabatic flame temperature, and the problem is reduced to the solution of the equations of motion. Howarth's solution for the two-dimensional jet based on the assumption of linear variation of viscosity with temperature is used and an approximate solution derived for the axially symmetrical jet. The theory gives a flame length directly proportional to volume flow. It agrees with experimental results at low flow rates but gives too high a value at the high flow rates. The discrepancy may be due to buoyancy effects or turbulence as well as other assumptions made in the analysis.

W. R. Hawthorne, England

2908. **Burgoyne, J. H., and Weinberg, F. J., "Excess energy" hypothesis of flame behaviour,** *Fuel* **33**, 4, 436–447, Oct. 1954.

Authors consider various aspects of flame phenomena from point of view of wave of excess energy. Latter arises as real quantity in phenomena insensitive to diffusion or when diffusion is actually negligible. This occurs in nonstationary processes. Inflammability limits or failure to propagate are indicated by calculated increase of excess energy at limits and accompanying heat losses from flame. Ease of ignition implies magnitude of excess energy distribution in a particular region—energy concentration. Increase of latter as inflammability is approached leads authors to suppose greater ignitibility for limit mixtures, though propagation may be more difficult. Experimental appearance of flame kernels and low temperature reactivity of lean mixtures are pointed to as supporting evidence. Flame extinction or quenching is due to diminution of excess energy wave by increased heat loss to walls, etc. Propagation of flame from ignition source is analyzed from point of view of minimum excess energy concentration and minimum ignition volume—implying minimum total ignition energy. Theory is developed to show relation between minimum spark ignition energy producing ignition in minimum volume, that is, minimum energy concentration for ignition vs. calculated excess energy concentration. The latter is proportional to $r_0 \int^{T_f} (k/T)dT$, k being average thermal conductivity. Good correlation is obtained for all mixtures of methane air between calculated excess energy concentration and measured ignition energy concentration.

M. Gilbert, USA

2909. **Olson, D. R., Wentworth, J. T., and Daniel, W. A., The evaluation of the energy released during preflame reactions,** *SAE Trans.* **62**, 606–618, 1954.

Authors have devised an improved thermodynamic method of evaluating energy release rate during preflame reactions in four-cycle gasoline engines. Major improvements are complete heat-transfer treatment and adaptation of entire calculation to machine calculation. Heat-transfer conductance was determined experimentally using fuel which does not exhibit preflame reactions.

Paper is predominately technique with enough data to show comparison of other existing methods of calculation. Authors' technique apparently offers some increase in accuracy and considerable increase in ease of calculation.

F. W. Bowditch, USA

2910. **Belles, F. E., and Berlad, A. L., Chain breaking and branching in the active particle diffusion concept of quenching,** *NACA TN* 3409, 37 pp., Feb. 1955.

General quenching-distance equations that take into account gas-phase chain breaking and branching and the effect of the wall efficiency for destruction of active particles are derived as extensions of the original simple theory of quenching by diffusion of active particles. The general characteristics of the equations are discussed. Quenching-distance data from the literature for propane-oxygen-nitrogen mixtures are treated in a consistent manner. The effects of elevated initial mixture temperature are predicted and agree qualitatively with observed trends. It is found that the simple theory correlates all the data satisfactorily.

From authors' summary

2911. **Morrison, R. B., A shock-tube investigation of detonative combustion,** Univ. of Mich. Engng. Res. Inst. Ann Arbor, 121 pp., 1955.

This is a reprint from a report of January 1952 describing experiment on gaseous detonation "produced by means of shock ignition." The results are correlated and rationalized on the basis of an analysis involving only the concept of a perfect gas with constant specific heat capacities to describe the thermodynamic properties of the substance. This allows for the presentation of all the results in terms of the Mach number of the detonation front. The analysis is described in detail, starting from basic principles.

A. K. Oppenheim, USA

2912. **Reynst, F. H., Pulsating-combustion gas turbines,** *J. Inst. Fuel* **28**, 169, 63–68, Feb. 1955.

Gas turbines of modern design, operating at 1200 F, may attain 31% thermal efficiency without regeneration if the pressure across the combustion chamber is increased from 6 atm to 8 atm. This increase in pressure is practicable with so-called pulsating combustion chambers. In this article, a method is described of combining pulsating combustion chambers with continuous-flow compressors and turbines.

From author's summary

Ballistics, Detonics (Explosions)

(See also Rev. 2716)

2913. Schardin, H., Measurement of spherical shock waves, *Comm. pure appl. Math.* **7,** 1, 223–243, Feb. 1954.

Paper is concerned with the development of the shock waves and other phenomena resulting from explosions. Examples are included of photographs obtained by multiple-spark schlieren, streak-camera, Kerr-cell, and x-ray photography; pressure measurements made with a condenser microphone are also described. The experimental results are found to be in reasonable agreement with calculations made by F. Wecken using the method of characteristics. D. W. Holder, England

2914. Ehricke, K. A., A new supply system for satellite orbits—Part I, *Jet Propulsion* **24,** 5, 302–309, Sept.-Oct. 1954.

The subject of orbital supply is investigated, stressing the engineering possibilities for improving the economic aspects of orbital operations and space flight. Following a brief survey of the basic problems, a new orbital supply system is proposed in the second section. It is characterized by operational separation of cargo supply and passenger transport. The supply ship has a ballistic shape and is automatically guided into the target orbit. The passenger ship is equipped with a winged upper stage. In the third section, supply requirements for orbital operations as well as space flight are discussed. The existence of optimum satellite orbits for departure and arrival of interplanetary expeditions is demonstrated analytically. Finally, examples of guided supply vehicles and passenger ships are presented. Their take-off weight and payload capacity serve to illustrate the effect of supply requirements on the over-all supply efforts.

From author's summary

2915. Kaeppeler, H. J., On the problem of cooling nuclear working fluid rockets operating at extreme temperatures, *J. Brit. Interplan. Soc.* **14,** 2, 89–97, Mar.-Apr. 1955.

For an eventual application of nuclear power for rocket propulsion, the solution of the cooling problem for nuclear working fluid rockets is of primary importance. A method for cooling linear heat sources is suggested and studied. Possible local temperature reductions due to dissociation and ionization are studied. A complete heat-conduction coefficient is defined. Examples show that even at operating temperatures very much beyond 10,000 K, sufficient cooling efficiency may be expected.

From author's summary

Soil Mechanics, Seepage

2916. Hansen, J. B., Earth pressure calculations, Copenhagen, Danish Technical Press (Teknisk Forlag), 1953, 271 pp.

Author approaches the problem of earth pressures against retaining structures of all types from the point of view of "limit analysis," based on the state of failure within the earth mass. He establishes a connection between the "extreme" methods and the "equilibrium" methods. The former (Coulomb, Fellenius, Rendulic) use a single condition of equilibrium together with a maximum or minimum condition; the latter consider all three statical conditions of equilibrium, using Kötter's equation to determine the internal forces on the rupture line.

Author combines both methods, considers various types of zone ruptures, line ruptures, and composite ruptures in the soil, and eliminates those which are not kinematically and statically possible. The distribution of earth pressures against the structure which is finally obtained corresponds to the type of soil failure selected and to that type only.

A number of design examples are given. To facilitate the somewhat complicated computations, charts and tables for some of the functions are included, which correspond to values of the angle of internal friction $\phi = 0$ and $\phi = 30°$.

G. P. Tschebotarioff, USA

2917. Stabilization of soils: Handy, R. L., Davidson, D. T., and Chu, T. Y., Effect of petrographic variations of southwestern Iowa loess on stabilization with portland cement; Slate, F. O., and Yalcin, A. S., Stabilization of bank-run gravel by calcium chloride; Baker, C. N., Jr., Strength of soil-cement as a function of degree of mixing, *Nat. Res. Counc. Highway Res. Bd. Bull.* 98, 52 pp., 1955.

2918. Thompson, T. F., Foundation treatment for earth dams on rock, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 548, 21 pp., Nov. 1954.

2919. Karpoff, K. P., Stabilization of fine-grained soils by electroosmotic and electrochemical methods, *Nat. Res. Counc. Highway Res. Bd. Proc. 32nd Ann. Meet.*, 526–538, 1953.

Paper gives a brief explanation of the fundamental processes of stabilization by electroosmotic and electrochemical means and cites the work of early investigators. Author investigated the effectiveness of the two methods by laboratory tests on two soils. The first type, a sandy silt, was investigated in the laboratory during development of testing techniques; the second, a medium fat clay, was investigated to evaluate and check the technique and apparatus developed. Tests included grain-size distribution, plasticity, standard compaction, triaxial shear, base-exchange capacity, x-ray diffraction, microscopy, and others. Data include time of lowering of phreatic line by well-point and by electric-potential methods, relative permeability prior to and after electroosmotic treatment. From author's summary

2920. Habib, P., and Šuklje, L., Determination of rupture loads of foundations resting on a slightly permeable stratum of limited thickness (in French), *Ann. Inst. tech. Bât. Trav. publics* no. 83, 1147–1166, Nov. 1954.

A theory based on the circular slip plane is presented in which the fact that the slip plane should cut the surface at 45° is utilized. When the pressure distribution under the foundation is assumed uniform, the critical pressure under the band foundation is $2\pi c$ and it is independent of the depth of the clay layer and the load intensity. Other distributions of pressure and also the case when the shearing strength of clay varies linearly with depth were studied by similar methods. Results were checked by experiments in the laboratory. T. Mogami, Japan

2921. Sawada, T., On the method to increase bearing power of foundations by consolidation of a highly compressible foundation, *Proc. 1st Japan nat. Congr. appl. Mech.*, 1951; Nat. Committee for Theor. appl. Mech., May 1952, 271-280.

Using the example of an enclosure bank for land reclamation, author solves the problem of a clayey foundation of taking into account the growth of strength due to consolidation below the dam when computing the bearing capacity. Detailed mathe-

matical solution is given, based upon Terzaghi's theory of consolidation. Linear decrease of pressure caused by dam weight to the depth is supposed. The results show the growth of bearing capacity after 1 and 2 years (1.4 and 1.6 times). In addition to the influence of dam weight, the weight of the clay mass under water is also inserted as an initial neutral pressure in a depth of layer, which is not quite clear. As clayey foundation material is extraordinarily weak (friction angle only 50 minutes, cohesion only 0.04 kg per sq cm), there is a need for index properties and geological classifications of this material.

V. Mencl, Czechoslovakia

2922. **Grasshoff, H., Settlement calculations for rigid foundations using the "characteristic point"** (in German), *Bauingenieur* **30, 2**, 53–54, Feb. 1955.

Author uses "characteristic point" concept (due to Van Hamme) for comparing by elastic theory the relative settlements of rigid and flexible surface footings. At the "characteristic point" on two footings, one rigid, one flexible, there would be the same settlement under equal (uniform) loading. Values obtained for distances of the characteristic point from the footing center or center line are 0.845 b, 0.74b, 0.71b (b = radius or half width) for circular, infinite strip, and square footings, these last being treated as circles of equal area. T. K. Chaplin, England

2923. **Ferrandon, J., The mechanics of permeable soils**—I, (in French), *Houille blanche* **10,** 1, 63–85, Jan./Feb. 1955.

This second article [for part I, see AMR **8,** Rev. 1867], based on lectures at the Grenoble Polytechnic Institute, deals with the equilibrium of cohesionless or frictionless soils under load, account being taken of seepage forces. Cauchy's method of characteristics is used and a number of examples involving frictionless soils are treated in an elegant manner. R. E. Gibson, England

Micromeritics

(See also Revs. 2755, 2772, 2773, 2928)

2924. **Smoldyrev, A. E., Various rules applying to the pneumatic transportation of filling materials through pipes** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **95,** 3, 469–472, Mar. 1954.

Paper shows that the equation for the pressure drop commonly adopted in considerations of pneumatic transportation is far from satisfactory for many materials. An attempt is made to find general rules applying to the forces of resistance in the case of pneumatic transportation of granular filling materials. The general form of the law of resistance is deduced by methods based on considerations of similarity. Experimental data are used in order to determine the coefficient of resistance.

J. Beránek, Czechoslovakia

Geophysics, Meteorology, Oceanography

(See also Revs. 2644, 2800)

2925. **Sukkar, Y. K., and Cornell, D., Direct calculation of bottom-hole pressures in natural gas wells,** *J. Petr. Technol.* **7,** 3, 43–48, Mar. 1955.

In natural gas wells, bottom-hole pressures may be determined by calculation or by direct measurement. Since measurement of the bottom-hole pressures is usually quite costly, it is desirable to obtain these pressures by calculation. A method of calculation of bottom-hole pressures is described which provides a direct solution for static and flowing bottom-hole pressures without recourse to trial-and-error methods. Integration of the differential equation is made contingent upon the validity of the assumption that a constant average temperature obtains in the system. Charts for the direct calculation of bottom-hole pressures are given in the paper. S. R. Faris, USA

2926. **Schmitz, H. P., Equation system for the vertical exchange of water vapor and heat content** (in German), *Z. Meteor.* **8,** 11/12, 352–369, Nov./Dec. 1954.

For moist air, equations, which decide the coefficient products between vertical velocity and the deviation of various state variables from their mean values by known *austausch* coefficients of potential temperature θ and specific humidity α, are derived with Dalton's law, the equation of state, definition equation of θ and α, and the equation of continuity. The differential equation for vertical distribution of mass transport by turbulence is given and plays an important role, instead of the groundless assumption used by Wilh. Schmidt (no mass transport by turbulence, neglect of turbulent fluctuation of pressure).

H. Arakawa, Japan

2927. **Payne, L. E., A note on a paper by Davies and Walters on "The effect of finite width of area on the rate of evaporation into a turbulent atmosphere,"** *Quart. J. Mech. appl. Math.* **7,** part 3, 283–286, Sept. 1954.

The solution given by Davies and Walters [AMR **5,** Rev. 1587] for the concentration of water vapor at any point in a turbulent atmosphere above an infinite rectangular saturated area may be transformed into a form which is more suitable for computational purposes. The integral expression for the solution given by these authors is replaced by a rapidly converging hypergeometric series.

From author's summary

2928. **von Glahn, U. H., Gelder, T. F., and Smyers, W. H., Jr., A dye-tracer technique for experimentally obtaining impingement characteristics of arbitrary bodies and a method for determining droplet size distribution,** *NACA TN* 3338, 73 pp., Mar. 1955.

The experimental details are given for applying a rather difficult technique. Dyed water is collected on blotting paper and strips are analyzed colorimetrically. E. Brun of ONERA has described similar methods using photographic paper in a spray of developer solution or methylene blue on a glossy paper. Authors show surprisingly small deviations from analytical trajectory solutions in view of difficulty of keeping uniform spray, low tunnel turbulence, and nonhomogeneous clouds.

M. Tribus, USA

2929. **Thompson, P. D., Prognostic equations for the mean motions of simple fluid systems and their relation to the theory of large scale atmospheric turbulence,** *Tellus* **6,** 2, 150–164, May 1954.

Purpose of the author is to develop a system of equations for the averaged motions of certain idealized fluids whose behavior is, in many aspects, similar to that of the middle and upper troposphere. He uses space averages, the mean value $\bar{\varphi}(x, y)$ of a function $\varphi(x, y)$ being defined by

$$\bar{\varphi}(x, y) = (a^2/2\pi) \int\int K_0(\alpha r)\phi(\xi, \eta)d\xi d\eta$$

where K_0 is the zero-order Bessel function of the 2nd kind and $r^2 = (x - \xi)^2 + (y - \eta)^2$, α being an arbitrary positive number,

the "scale parameter"; due to the introduction of the weight K_0, the averaging process has properties essentially different from those of the well-known averaging process used by Reynolds for the Navier equations. The fundamental feature of this bar operator is that $\overline{\nabla^2\varphi} = \nabla^2\bar{\varphi} = \alpha^2(\bar{\varphi} - \varphi)$. Using this averaging process, the equations of mean motion for an incompressible autobarotropic fluid are given. Some connections of the equations of mean motion to the theory of diffusion (based on mixing-length assumptions) are investigated.

J. Kampé de Fériet, France

2930. Deirmendjian, D., and Sekera, Z., Global radiation resulting from multiple scattering in a Rayleigh atmosphere, *Tellus* **6,** 4, 382–398, Nov. 1954.

Using Chandrasekhar's solution for the radiative transfer problem in a plane-parallel model of the earth's atmosphere, under the assumption of perfect conservative scattering according to the Rayleigh law, expressions are derived for the relative global and sky radiation received on a horizontal surface, as a function of normal optical thickness and inclination of incoming parallel radiation. The corrections representing the effect of ground reflection are also expressed in terms of certain functions already defined by Chandrasekhar. These expressions, which include the effect of all orders of scattering, are then used to compute the absolute global and sky radiation as a function of wave length and solar zenith distance, based on the solar extraterrestrial energy curve as given recently by Nicolet. The results show that, under these assumptions, the global radiation received at the surface of the earth should remain essentially constant in spectral distribution for a wide range of solar altitudes, and that the pure sky radiation should have two maxima, centered at 3300 Å and 4100 Å, respectively, for solar zenith distances ranging between 0° and 45°.

The theoretical work is compared with Bernhardt's results obtained by means of certain simplifying assumptions about the successive orders of scattering.

The absolute global and sky radiation is integrated over the range 0.29 to 4.00, and it is shown that, in general, the computation is in good agreement with existing measurements under clear sky conditions.

From authors' summary by A. Whillier, South Africa

2931. Drummond, A. J., and van Deventer, E. N., The atmospheric transmission of solar radiation over Southern Africa, *NOTOS, South African Weather Bureau, Pretoria* **3,** 4, 272–286, 1954.

Concern is primarily with the depletion of the solar beam during its traverse of the terrestrial atmosphere over Southern Africa. Records for eight stations, six of which are operating at present in the South African Bureau network (one with the cooperation of the Madagascar Meteorological Service), are examined. Both total and diffuse radiation are reported, and the atmospheric transmission is derived.

Comparisons are drawn with other regions of the world for which representative surface measurements were obtainable. Radiation income in Southern Africa is strikingly higher than anywhere else with records of solar radiation. The value of the total terrestrial albedo is discussed and an estimate is made of the contribution by Southern Africa to the global figure. An account is given of the radiation program of the South African Weather Bureau and of the facilities set up in Pretoria for the advancement of meteorological radiation research throughout Africa.

A. Whillier, South Africa

Lubrication; Bearings; Wear

2932. Osterle, F., and Saibel, E., Recent advances in the hydrodynamic theory of slider-bearing lubrication—The Reynolds equation, First Ann. Conf. ASME-ASLE, Baltimore, Md., Oct. 1954. Pap. 54—LUB-15, 10 pp.

Present paper contains a report on nine theoretical papers of the authors and their co-workers which deal with the lubrication of sliders. These dissertations are based on the assumption that the film is so thin that pressure, density, and viscosity of the lubricant can be regarded as independent of the thickness coordinate. Under this supposition, the Reynolds equation is valid even if variation of viscosity with pressure or temperature shall be taken into consideration.

Starting from this hypothesis, the load capacities of rectangular and sector sliders with exponential profiles without and with side leakage were calculated. Further, in the case of a rectangular slider, the effect of a transverse exponential curvature was also determined.

Then, in order to demonstrate that load capacity and friction under nonsteady conditions differ markedly from the predictions of the steady-state theory, authors treated the problem of tilting-pad slider subjected to a sinusoidal pivot vibration normal to the slider surface.

Consideration of the viscosity-pressure-dependence leads to an equation which can be reduced to Reynolds equation for constant viscosity μ_0 by introduction of $p^x = \mu_{0\,0}\int^p (dp/\mu)$, wherein p is the pressure and μ the viscosity. Thus, taking the widely recognized viscosity-pressure-relation $\mu = \mu_0 e^{\alpha p}$, one can get the pressure distribution from the pressures p^x calculated with the constant viscosity μ_0 by the equation $p = -1/\alpha \ln(1 - \alpha p^x)$.

To take account of the viscosity-temperature-dependence, the energy equation must be solved simultaneously with the Reynolds equation. By such proceeding, the pressure and temperature distributions along an inclined slider were determined for the adiabatic case under supposition of the viscosity-temperature-pressure-relation $\mu = \mu_0 e^{dp-\gamma t}$ (t = temperature).

Further, the temperature dependence of density was taken into account. It causes a load capacity also in the case of a parallel surface slider. This was shown by solving the momentum and the energy equation simultaneously under the assumption that the density ρ varies with temperature according to $\rho = \rho_0 e^{-M}$.

Lord Rayleigh had already solved the question of which slider-profile yields the highest load capacity. Whereas Lord Rayleigh had assumed a constant viscosity, authors treated this problem under supposition of a viscosity which varies with pressure. Both calculations, for the case of no side flow performed, demonstrated that the stepped slider has the best load capacity. Finally, under conditions of adiabatic flow, stepped slider was studied with viscosity depending on temperature and pressure.

U. Rost, Germany

2933. Dubois, G. B., and Ocvirk, F. W., Analytical derivation and experimental evaluation of short-bearing approximation for full journal bearings, *NACA Rep.* **1157,** 32 pp., 1953.

Supersedes articles reviewed in AMR **6,** Revs. 2384, 1443.

2934. Heinrich, G., and Desoyer, K., The lateral buckling stiffness of a single-acting thrust bearing floated by an incompressible medium (in German), *Öst. Ing.-Arch.* **8,** 2/3, 138–149, 1954.

Authors deal with a problem of mainly academic interest. A rather involved calculation proves analytically that the flow under a rotating circular plate, slightly inclined around an axis in its

plane, creates a restoring moment of almost negligible amount, this latter fact being well known from practice.

A. Slibar, USA

2935. **Katto, Y., and Soda, N., Theory of lubrication by compressible fluid with special reference to air bearing,** *Proc. 2nd Japan nat. Congr. appl. Mech.*, 1952; Nat. Committee for Theor. appl. Mech., May 1953, 267–270.

2936. **Niemann, G., The formation of the lubricating film, power loss, and damage limits of gears with evolute teeth** (in German), *ZV DI* **97,** 10, 305–308, Apr. 1955.

Starting from hydrodynamic lubrication theory, under certain assumptions an approximate solution is presented for gears. From it follow the equations for the magnitude and the change of thickness of the oil film, the oil pressure, and the power losses at the flanks of the teeth. The limitations of the theory and the directions in which it should be improved are discussed. The agreement between theory and experiment is good in the region of the liquid friction. Making use of the limiting values, which depend on the formation of the oil film, on the fatigue strength of the material under Hertzian pressure, and on conditions at the root of the tooth, the limiting lines are determined as a function of the circumferential force and velocity.

R. G. Boiten, Holland

Marine Engineering Problems

(See also Revs. 2761, 2764, 2765, 2768)

2937. **Staff of SSPA (Edited by H. Lindgren), The influence of propeller clearance and rudder upon propulsion characteristics,** *Medd. SkeppsProvAnst.* no. **33,** 25 pp., 1955.

Experimental investigations into the influence of (a) propeller clearance and aperture form and (b) rudder and its thickness on propulsive characteristics. For (a), tests were made on a cargo ship model, block coefficient 0.656. Aft and forward positions of the propeller were altered and also the shape of the aperture by fitting a plate in the plane of the center line. In spite of considerable differences in clearance and aperture form, maximum variation of propulsive coefficient was ±2%. For (b), experiments were conducted on tanker model, block coefficient 0.750. Presence of rudder increases thrust deduction factor. Increase of propulsive coefficient depends on thickness-length ratio of the rudder. Optimum ratio is about 0.20 with which gain is about 5%. The wake fractions are calculated by means of results from both normal and "with rudder" open water tests. In the latter case, wake fractions are practically independent of the presence of the rudder.

H. W. Lerbs, USA

2938. **Lackenby, H., On the presentation of ship-resistance data,** *Quart. Trans. Instn. nav. Arch. Lond.* **96,** 4, 471–480, 6 figs., Oct. 1954.

Schemes for presenting resistance data are reviewed, mainly to determine those most convenient for design purposes. Resistance per unit displacement is recommended as the most useful criterion for performance comparison of different ship forms. Resistance data should thus be presented in terms of (1) resistance coefficient and Froude number based on displacement, or (2) resistance coefficient based on displacement per unit length and Froude number based on ship length. Forms of presentation more suitable for investigations into the physical nature of resistance are also discussed.

W. L. Haberman, USA

2939. **Tamiya, S., On resistance experiments of ship models,** *Inter. Shipbldg.* **1,** 2, 55–60, 1954.

2940. **Sokolova, I. N., and Grigorash, Z. K., On the vertical oscillations of the center of gravity of a ship moving with constant velocity in progressive waves** (in Russian), *Izv. Akad. Nauk SSSR Ser. Geofiz.* **1954,** 280–287, 1954.

Authors consider a thin (Michell) ship moving in regular waves on deep water with constant horizontal velocity c and a vertical (heaving) velocity $v(t)$ (to be determined); pitching motion is apparently excluded. The velocity potential for the absolute motion of the water, in a moving coordinate system, is taken in the form

$$\Phi(x, y, z, t) = ag\sigma^{-1}e^{kz}\cos(kx - \sigma t) + cx + \varphi(x, y, z, t)$$

The boundary condition on the ship is taken as

$$c\partial f/\partial x + v(t)\partial f/\partial z = \pm\partial\varphi/\partial y \quad \text{for} \quad y \gtrless 0$$

[Since the linearized boundary condition is used on the free surface, one would expect the boundary condition on the ship also to be linearized in some consistent manner (cf., e.g., John, *Comm. Pure appl. Math.* **2,** 13–57, 1949, especially p. 22 ff; AMR **2,** Rev. 1521).] It seems to the reviewer that the second term on the left would occur among the second-order terms in any systematic linearization procedure. The authors' introductory remarks to this boundary condition seem to indicate that they have selected it on the basis of intuition.] Authors find φ in terms of f_x, f_z, and $v(t)$, find the vertical component of the pressure, and write down the differential equation for the vertical motion of the center of gravity of the ship. This equation is analyzed for resonance phenomena, particularly when $f_z = X(x)Z(z)$, $X(-x) = X(x)$. For such a ship moving in a following sea there is a critical velocity above which there is no resonance.

J. V. Wehausen, USA

2941. **Voigt, H., Some recent experiences in connection with vibration of ships** (in German), *Jahr. Schiffbautech. Gesellsch.* **47,** 260–273, 1953.

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